Plants and people in the later prehistoric and Norse periods of the Western Isles of Scotland

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Certification of originality:

This is to certify that this thesis has been composed by the author and that the work is the authors own, except for collaborative research indicated in the text. Also, the work has not been submitted for any other degree or professional qualification, except as specified.

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Abstract

The first millennia BC and AD were a key period in the settlement history of Atlantic Scotland. There is a dramatic increase in the number and diversity of archaeological monuments, many of which are domestic in nature. The sites contain thousands of ecofacts and artefacts, allowing detailed insights into the workings and developments in everyday life across many different sites for the first time. The use of plants by humans would have been an essential component in many of these developments. Prior to this study, little direct evidence for human / plant interactions during this period was available in the Western Isles, a pivotal location in the wider North Atlantic realm.

The research focuses on the analysis and interpretation of new carbonised plant macrofossil assemblages from nine multi-period sites in Lewis, the largest island in the Western Isles. A regional sampling strategy was employed, allowing direct statistical comparison of the archaeobotanical remains. Due consideration is given to the taphonomy of the carbonised plant assemblages. A generic model is proposed for most remains, involving the carbonisation of the plant material on household fires, followed by the spread of the ash and the carbonised material across the sites by various anthropogenic and natural transforms. Measurement of the mineral magnetic signatures of on-site sediments supports this model, highlighting both the distribution of ash and its correlation with macrofossil concentration in the stratigraphy. A new technique was also developed, using mineral magnetic measurements of experimental fire ash to source the fuels used in the household fires. Application of this technique to ash from the archaeological sites indicated that well-humified peat was the principal fuel employed.

Four interpretative research themes relating to the use of plants are then addressed. These include the arable economy, the management and procurement of wood and timber, the deliberate gathering of plants and the social dimension of plant use. Integration of these research themes resulted in the construction of a generic economic landscape and annual cycle of the human / plant interaction, requiring sophisticated systems of social co-operation, territoriality and land-division. Comparative analysis demonstrates that the economic landscape varied over time and space and also changed subtly over the wider region of Atlantic Scotland.

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Contents

Figures

Tables

Appendices

Conventions and abbreviations

The following abbreviations have been employed for the various site blocks analysed in this study. In general the abbreviations follow the words used by the excavators to describe the phases. For example the earliest block at **D**un **B**harabhat, described by the excavator as the **P**rimary phase, has been abbreviated to **DB-P**.

AD-IA = **A**n **D**unan **I**ron **A**ge block
AD-M = **A**n **D**unan **M**edieval block
AD-U = **A**n **D**unan **U**nphased block
BO-E = **Bo**stadh **E**arly block
BO-LIA = **Bo**stadh **L**ate **I**ron **A**ge block
BO-LIA/N = **Bo**stadh **L**ate **I**ron **A**ge / **N**orse transition block
BO-N = **Bo**stadh **N**orse block
BO-U = **Bo**stadh **U**nphased block
CC-1 = **C**alanais Kerb cairn Phase **1** block
CC-2 = **C**alanais Kerb cairn Phase **2** block
CC-3 = **C**alanais Kerb cairn Phase **3** block
CC-4 = **C**alanais Kerb cairn Phase **4** block
CC-U = **C**alanais Kerb cairn Phase **U** block
CN-W = **Cn**ip **W**heelhouse block
CN-C = **Cn**ip **C**ellular block
CN-R = **Cn**ip **R**ectilinear block
CN-U = **Cn**ip **U**nphased block
DB-P = **D**un **B**harabhat **P**rimary block
DB-M = **D**un **B**harabhat **M**ain block
DB-S = **D**un **B**harabhat **S**econdary Occupation block
GAL-LIA = **Gal**son **L**ate **I**ron **A**ge block
GAL-N/M = **Gal**son **N**orse / **M**edieval block
GE = **G**ob **E**irer site block
GUN-IA = **Guin**nerso Iron Age block
LB-PR = Loch na **B**eirgh **P**re-**R**oundhouse block
LB-R = Loch na **B**eirgh **R**oundhouse block
LB-C = Loch na **B**eirgh **C**ellular block
LB-I = Loch na **B**eirgh **I**ntermediate block
LB-LIA = Loch na **B**eirgh **L**ate **I**ron **A**ge block
LB-U = Loch na **B**eirgh **U**nphased block

The general convention for describing plant names in the text involved the use of common names and the scientific name in brackets for the first mention of wild components in each chapter. Thereafter, the wild components are described with the common name only. The first time a cultivated plant or tree / shrub is mentioned in the text, both the common name and the scientific name are given. Thereafter, only the common name is given in the remainder of the thesis. A full list of the common and scientific names for each plant element and type identified is given in Table 3.5. When using common names, genus level identification is given in lower case (e.g. birch), whereas species level identification is given in capitals for the first word (e.g. Silver birch).

Generic context types have also been abbreviated in many of the data tables; see Table 3.7 for list of generic context types, appropriate descriptions and abbreviations.

Chapter 1: Introduction

1.1 Reconstructing the human / plant interaction

It is hard for us to appreciate the importance of plants to our everyday life. Our world is dominated by synthetic material and most Scottish urban dwellers buy their food rather than grow it. The furnishings that now surround us will have an element of wood within them but much of the material is made of plastics, metal and other artificial material. Importantly, few of us know where and how the plant material we use was processed, we just take it for granted. However, this is a post-industrial phenomenon, a product of our 21st century market economy. If we look back at the recent centuries in Atlantic Scotland, those parts of Scotland on the Atlantic land / sea interface running from Argyll in the west round to Caithness in the east (Figure 1.1; Piggott, 1966), life was very different. People were much more aware of the importance of plants to many aspects of their life, be it for food, as building material or part of their wider economic and social landscape.

We can reconstruct most aspects of these human / plant interactions in the recent past through examination of local statistical accounts and ethnographic observation (cf. Martin, 1716; Fenton, 1978; Bennett, 1994; Smith, 1994). In the case of Bereiro, an abandoned blackhouse village in Lewis, these observations have been supported by a detailed survey of the deserted blackhouse village and surrounding infield/outfield system (Burgess *et al.*, 1999). Trial excavation was also undertaken of an earlier building underlying one of the blackhouses to try to retrieve dating for possible Medieval settlement (Burgess *et al.*, 1997e). Several bulk samples were taken from the excavations yielding carbonised plant macrofossils of six-row hulled barley (*Hordeum vulgare* var. *vulgare* L.), known in Atlantic Scotland as bere barley, oats (*Avena* sp.) and various wild seeds and charcoal including spruce (*Picea* sp.) driftwood (Table 1.1). The ecofacts corroborated the evidence of the major crop and wood sources from the statistical and ethnographic accounts, as well as providing more detailed evidence on possible cultivation practices. However, ethnographic observation only goes a little way back when considering the length of time Atlantic Scotland has been settled. Traces of human occupation have been discovered almost to the beginning of our present interglacial 10000 years ago (Wickham-Jones, 1994). If we want to investigate the human / plant interactions during prehistory we have to turn to palaeoenvironmental proxies, chiefly the study of plant macro and microfossils.

Plant microfossils consist of plant material, such as pollen grains and spores, which can only be viewed under high powered microscopes and are usually collected from loch sediments and peat profiles to reconstruct palaeoenvironmental change over thousands of years within the catchment of the loch or bog. Plant macrofossils can be seen with the naked eye and include material as small as the carbonised weed seed of a cereal crop through to large timbers preserved within waterlogged conditions. The chronological, spatial and interpretative resolution of plant macrofossils compared to microfossils is different. Microfossils usually reflect continuous and long-term environmental change on a regional scale, whereas macrofossils reflect the direct use of the plant resource by humans at a specific point in space and time. This interpretative difference means that the direct human / plant interaction of a region within a set period is best approached through a detailed analysis of macrofossil assemblages from a number of archaeological sites of overlapping chronology, supported by a picture of the regional environment provided by pollen and other similar palaeoenvironmental proxies. This study outlines the analysis of nine macrofossil assemblages from archaeological sites in West Lewis as a case study for interrogating the human / plant interaction of the first millennia BC and AD in Atlantic Scotland.

1.2 Archaeology in Atlantic Scotland

The archaeology of Atlantic Scotland is a unique cultural resource within north-west Europe. The abundance, diversity and preservation of many classes of archaeological remains are at odds with the modern perception of environmental, economic and political marginality. Sophisticated social systems would have been in place for millennia, judging by the legacy of the monuments ranging from Neolithic stone circles through to Medieval strongholds. These include the magnificent ritual landscape of Calanais, the impressive broch towers such as Mousa and Dun Carloway, the eroding multi-phase settlements from large expanses of sand and dunes including the large Norse farm mounds in the Northern Isles, and the large expanses of Medieval and post-Medieval deserted townships and field systems that cover much of the cultivable land in the region. Many excavations, some undertaken in the 19th century, have matched this settlement history with impressive collections of artefacts and ecofacts of all ages that have been recovered from the detailed stratigraphy, sometimes metres deep, associated with many of these sites. The site based archaeology is also complemented by direct and indirect landscape proxy records, including relic field systems and old ground surfaces, as well as various sediment traps, such as lochs and peat profiles, which record landscape change over millennia through palaeoenvironmental techniques such as palynology. The survival of these archaeological sources is the result of a complex interplay of various factors of preservation. Many of the monuments consist of the remaining shells of masonry, sometimes metres high, that protect the stratigraphy and material culture deposited within them. Some of these deposit types are excellent preservation systems for material not usually found in lowland Britain. The material includes uncarbonised plant macrofossils and wood, insect remains and even leather in waterlogged conditions. The calcareous wind blown shell sands that fringe many of the islands and some of the mainland in the region provide an excellent medium for the preservation of bone and shell. Also, these wind blown sands and other naturally deposited sediments, such as blanket bog and estuarine material, can cover the sites almost immediately post-abandonment protecting the archaeology. Indeed, one of the most important preservation factors in Atlantic Scotland is the lack of agricultural intensification seen in lowland Britain since the Industrial Revolution that has severely truncated the archaeological record. In summary the formation and preservation of all these lines of evidence contribute to an almost unparalleled resource for understanding the past.

The first millennia BC and AD were a particularly interesting and important period in the settlement history of Atlantic Scotland. The first millennium BC saw a dramatic increase in the number and size of monuments and many of these are domestic in nature, allowing detailed inter-site economic reconstruction of everyday life for the first time. The houses themselves also displayed increased evidence of monumentality culminating in the construction of broch towers in the second half of the millennium. The construction of these monuments must have required sophisticated social systems and support networks. At the beginning of the first millennium AD, Atlantic Scotland represents one of the few areas in Western Europe that had no direct colonisation by the Romans. It is therefore possible to investigate any continuity of indigenous economic and social practices that were not directly altered by the presence of the Romans. However, throughout the rest of the millennium it is likely that many outside influences were felt, including the exchange of ideas and people from the Atlantic seaboard, that culminated with the Norse expansion in the final centuries (see Section 2.6 for detailed discussion).

1.3 Introducing the scope and research aims of the study

The use of plants by humans would be an essential component in many of these developments and it is the intention of this study to illuminate the human / plant relationships during this important period of Atlantic Scottish archaeology. This study focuses on new carbonised plant macrofossil assemblages from nine sites of later prehistoric and Norse date. All of the sites are in West Lewis in the Western Isles. It was reasoned that an intensive study within a relatively small study area would allow more detailed analysis of the human / plant relationship, especially within a self-contained island system. It is possible to define limits and zones in terms of environmental and social landscapes of island systems and so they are ideal for an holistic approach in archaeological investigation (Bond, 1998). Lewis is an excellent island for a study of this nature within the wider context of Atlantic Scotland as it has a very rich archaeology. However, relatively little was known of the use of plants prior to the sampling of the sites described by this research. This was in contrast to the detailed sampling exercises previously undertaken in other island systems such as the Northern Isles and the Southern Hebrides. Also, the infrastructure of a regional research project, the Calanais Archaeological Research Project of the Department of Archaeology, University of Edinburgh was in place at the initiation of the research.

However, the research was not undertaken in a knowledge vacuum. A number of research themes that could be addressed from the carbonised plant macrofossil assemblages are apparent from archaeobotanical reports from extensive sampling programmes in Atlantic Scotland published prior to the initiation of the research (cf. Boardman, 1993, 1995a; Dickson, 1994). These themes can be split into two broad categories, methodological and interpretative.

The first methodological research theme relates to the way that sites are sampled. Prior to 1995 most archaeobotanical assemblages in Atlantic Scotland stemmed from single site excavations. Though most samples were taken from extensive multi-phase settlements allowing useful intra site comparison between different phases, the sampling strategies employed on each of the sites were slightly different meaning that inter site comparison was more difficult. van der Veen (1992) had demonstrated the interpretative value of a statistically valid regional sampling strategy, allowing detailed statistical interpretation of archaeobotanical assemblages from a number of Iron Age and Romano-British sites in North East England. The first research aim was therefore to test and establish a regional sampling strategy allowing meaningful statistical inter site analysis.

The second methodological research theme relates to the way the carbonised plant macrofossil assemblages are formed (the taphonomy). It has been assumed, both within Atlantic Scotland (cf. Milles, 1986; Bond, 1994; Dockrill *et al.*, 1994; Dickson, 1994; Holden & Boardman, 1998; Smith, 1999) and Britain as a whole (Hillman, 1981; G Jones, 1984; M Jones, 1985, 1996; van der Veen, 1992), that much of the carbonised plant remains recovered from archaeological sites were most likely carbonised on household fires. A basic taphonomic model has been implicit within these studies that involves three stages; 1) the pre-charring derivation of the plant material incorporated into the fires through direct or indirect human discard 2) the process of charring and carbonisation within the hearth itself and 3) the subsequent spread of ash from the hearth into the archaeological contexts sampled. However, this assumption is rarely tested and so the taphonomy of the plant macrofossils will be investigated through the integration of complementary archaeological and environmental techniques, principally mineral magnetic analysis of the sediments. Also, appreciation of taphonomic biases is an essential stage prior to analysing and interpreting the plant / human interaction, as it informs the archaeobotanist of the detail and resolution of the research questions that can be asked of the data.

With a realistic appreciation of the problems in the sampling and taphonomy of the assemblages in place, the research themes relating to archaeobotanical interpretation can then be approached. Each of the research themes can be interrogated both spatially and chronologically. In other words, inter and intra site comparison can address issues of variation in plant use between sites during a specific time period as well as the construction of chronological narratives. The most obvious research theme relates to the arable economy of the sites under investigation. Basic research questions will be addressed on the types of crops grown, where they were grown and how they were processed. More sophisticated questions will also be asked on the spatial dynamics of the regional arable economic landscape, in an attempt to investigate "Archaeobotany beyond subsistence reconstruction" (Jones, 1985).

Atlantic Scotland in the first millennia BC and AD was an open landscape dominated by moorland fringed by relatively fertile coastal zones and seascapes. The open nature of the landscape meant wood and timber procurement was an important part of the economic system of most islands. Charcoal is one of the most ubiquitous ecofacts on sites in the region. However, comparatively little research on charcoal remains has been undertaken in the region, with the notable exception of a few detailed site reports (cf. Dickson, 1994; Crone 1998, 1999). Therefore, the second interpretative research theme to be addressed is the type of wood and timber used and the management and procurement strategies employed to maximise a scarce resource. The moorlands and coastal areas were also habitats containing a variety of plants useful to humans. The range of plant products gathered and their possible uses and management form the third interpretative research theme. The final research theme involves using the archaeobotanical assemblages as indicators of the social landscape in terms of social stratification and hierarchy, as well as the less prosaic uses of plants within the belief systems of the populations. The detailed research aims and questions from each of the themes are outlined in the following chapter.

The structure of the study reflects the preliminary data-gathering nature of the research. The next chapter outlines the archaeological and palaeoenvironmental background of Atlantic Scotland in general terms before concentrating in more detail on the Western Isles and Lewis in particular. Chapter 3 describes the methodologies used to approach the research questions, whilst chapter 4 describes the sites and their sampling and chronology. The following chapter then explores the formation of the carbonised archaeobotanical assemblages, highlighting the importance of hearths in this process. Chapters 6 and 7 then outline the results from the sites sampled, with continuity and change of the human / plant interactions examined on both a chronological and spatial scale. The observed interactions and models are then compared against published data from elsewhere in Atlantic Scotland.

Chapter 2: Palaeoenvironmental and archaeological background to the Western Isles

2.1 Introduction

This chapter introduces the environmental and archaeological background of the Western Isles and Lewis in particular. The key research themes and detailed aims of the study are also highlighted, many of which are informed by the present state of knowledge from both the archaeology and palaeoenvironmental reconstruction. The Western Isles are part of the wider archaeological zone of Atlantic Scotland. The region was first explicitly described by Piggott (1966) in his zonation of the Iron Age in Scotland (Figure 1.1). It runs from the mainland of Argyll in the west round to Caithness and Sutherland in the north east and encompasses the many hundreds of islands within the main groups of Skye, the Inner Hebrides and the Western Isles and the Northern Isles of Shetland and Orkney. Piggott recognised that the Iron Age of Atlantic Scotland was dominated by substantial upstanding stone structures including brochs, duns, wheelhouses and crannogs. The distinct character of Iron Age settlement was different to the highlands and lowlands of the mainland and the more southerly parts of Scotland including the south-west and the Borders.

Extensive palaeoenvironmental and archaeological research has been undertaken throughout Atlantic Scotland since Piggott delineated the region in the mid 1960s. There have been distinct phases and spatial focuses in the research, for example a spate of rescue and research led survey and excavation was undertaken in Orkney between the late 70s and mid 80s (cf. Hedges, 1987). Two general research approaches can be identified. The first involves detailed investigation of a single, generally multi-phase, site that was usually a result of a threat to the archaeology. The second involves a more multi-disciplinary and long-term research approach to a specific region or monument type. The latter approach is a relatively recent phenomenon and reflects the increased awareness of the landscape approach in British archaeology (cf. Cunliffe, 1995). These two approaches can be seen in both archaeological and palaeoenvironmental research. A number of significant multi-period excavations with substantial roundhouses as their focus have been published, such as Bu (Hedges, 1987), the Howe (Ballin-Smith, 1994) and St. Boniface (Lowe, 1999) in Orkney and Scalloway (Sharples, 1998) and Kebister (Owen, 1999) in Shetland. A number of long term research projects have also been initiated in the late 80's and 90's including the Calanais Archaeological Research Project (CARP; Harding, 2000) in Lewis by the University of Edinburgh (see below), the Freswick Links Environs Project in Caithness by the University of Glasgow (Morris *et al.*, 1995), the Sheffield Environmental and Archaeological Research Campaign in the Hebrides (SEARCH; Branigan & Foster, 1995; Gilbertson *et al.*, 1996a; Parker-Pearson & Sharples, 1999; Branigan & Foster, 2000) and the Jarlshof

Environs Project in Shetland, focussing on the substantial excavation of the Mid Iron Age to Norse remains at Old Scatness (Nicholson & Dockrill, 1998). Each of these research projects has identified the retrieval, analysis and integration of on and off site palaeoenvironmental records as key research themes.

The present landscape of Atlantic Scotland is dramatic and varied, though a number of general characteristics can be highlighted. Much of the region is denuded of trees creating a barren and windswept landscape, save for certain stretches of native woodland and conifer plantations on the mainland. Many pollen diagrams from throughout the region have confirmed that the open nature of the landscape has existed for thousands of years, with the large scale removal of tree cover from most of the island groups completed by the beginning of the first millennium BC. This has been shown by good examples of Late glacial through to Late Holocene pollen profiles in each of the main areas in Atlantic Scotland including Catta Ness in Shetland (Bennett *et al.*, 1992), Crudale Meadow in Orkney (Bennett *et al.*, 1997), Cross Lochs in Caithness (Charman, 1994), Rannoch Moor on mainland Argyll (Walker & Lowe, 1981), Oronsay (Birks *et al.*, 1987) and the Rinns of Islay (Edwards & Berridge, 1994). The removal of this tree cover is a function of the complex interplay of a number of climatic, pedogenic and anthropogenic factors. Many of the islands also have extensive tracts of blanket peat, bog and moorland that expanded at the expense of the forested areas and cultivable land in the mid Holocene. This has concentrated human settlement into coastal areas and low-lying areas and valleys running into the interiors of much of the region. Within these coastal areas are a number of sets of sandy beaches and allied geomorphic forms, such as the extensive machair plains of the Uists in the Western Isles. Indeed, the Western Isles have some of the largest areas of these calcareous shell sands as well as all of the other major landscape features characteristic of Atlantic Scotland. These include the high mountains of North Harris, the 'loch and lochan' landscape of North Uist, various estuarine expanses such as Broad Bay near Stornoway and the largest area of blanket bog in Britain within the interior of Lewis. It is this landscape variability, coupled with the excellent archaeological resource only recently begun to be tapped, which highlights the suitability of the Western Isles for investigating the human / plant interaction in the first millennia BC and AD.

2.2 Present environment of the Western Isles

Lewis is the largest land body in the arcuate chain of islands that makes up the Western Isles (Boyd & Boyd, 1990; Pankhurst & Mullin, 1994). The present landscape can be broadly separated into three main areas; the 'blacklands', 'whitelands' and the 'brownlands' (see Figure 2.1). The 'blacklands' cover most of the island and consist of a treeless subdued topography covered in blanket peat, dotted with literally hundreds of lochs of varying size and bare outcrops of Lewisian gneiss. The 'brownlands' on the other hand consist of agriculturally more viable land and soil on which most of the island's settlement is concentrated. This landscape zone fringes most of the coastal areas and its form is a function of the intervention of humans who improved the land for agricultural purposes over thousands of years. The 'whitelands' refer to the calcareous shell sands of the machair, a unique geomorphic phenomenon of the Western Isles.

The archaeobotanical assemblages that comprise much of the new evidence presented come from nine sites of later prehistoric through to Norse date. All are located in West Lewis, a function of archaeological visibility and relative proximity to the University of Edinburgh's research centre at Calanais Farm (see Figure 3.1). Five of the sites are located in the machair and allied 'whiteland' environs (Loch na Beirgh, An Dunan, Cnip, Bostadh, Galson), three within the improved land of the 'brownlands' (Calanais kerb cairn, Gob Eirer, Dun Bharabhat) and the single site of Guinnerso within the 'blacklands'. More detail on the sites and the sampling is given in Chapters 3 and 4.

The climate is held largely responsible for the widespread blanket mire and generally treeless appearance of the island. Lewis has the classic maritime climate of Atlantic Scotland, with a small annual variation in mean temperature, high rainfall and high wind speed. The temperature is generally quite cool, though there is a lack of very cold winters with an average of only 7 days on which snow lies on the ground (Angus, 1994), approximately 225 days for the growing season (Macaulay Institute, 1982) and only a small annual range in temperatures. The high rainfall in Lewis results from Atlantic depressions. For Stornoway an average of 1100 mm a year falls but this varies with relief and altitude with up to 2400 mm a year on some of the higher summits of Harris (Angus, 1994). This high rainfall with low levels of evaporation have led to a long history of water surpluses over Lewis, resulting in severe leaching of the soil and the formation of peaty podzols, peaty gleys and ultimately peat. Lewis is said to have the highest average wind speeds in inhabited areas of north west Europe (Gloyne, 1968) with much of the island being classified as 'very exposed' (Birse & Richardson, 1970). This severely stunts the growth of plants and leads to the spread of dwarf shrub varieties such as Ling Heather (*Calluna vulgaris* L. Vill.) and Juniper (*Juniperis communis* L.). The high wind speeds have contributed, along with the inhospitable soils and grazing, to the lack of widespread tree cover in the modern landscape.

To summarise, most of Lewis is covered by a mosaic of moor, bog and loch fringed by more amenable soils which act as the present and historic land use focus. The development of the interior was largely controlled by climate and has been ongoing for thousands of years. Hence of particular interest is the environmental change that occurred on the coastal zones of the 'whitelands' and 'blacklands' and how the human population responded. The environmental reconstruction needed to understand this change involves the integration of many lines of evidence from the solid geology through to analysis of individual pollen profiles from across the study area.

2.3 Geology, geomorphology and pedogenesis

The metamorphic gneisses and related rocks of Lewis are amongst the oldest in Britain, some formations dating to 2800 million years (Gribble, 1994; Edwards *et al.*, 1994). Figure 2.2 shows the almost exclusive coverage of basement rock of Lewisian gneiss in the region. This solid geology gives

Lewis a subdued and undulating landscape with occasional upland areas such as the igneous complex in South Harris. This landscape is ideal for the development of widespread blanket peat (Moore 1993). The drift geology is much more complex and ephemeral and represents a palimpsest of evidence common to Atlantic Scotland due to truncation by repeated glaciation. However 'snap-shots' of evidence are located across Lewis and Harris and these are summarised in Table 2.1 (for location of sites mentioned see Figure 2.3). Quaternary glaciation produced a landscape of complex relief with rocky outcrops, small hollows (now filled by peat and water), extensive till deposits and erosion and meltwater features related to glacio-fluvial action.

The key concept to Lewisian sea level change in the Holocene is one of submergence. This differs from other areas in Atlantic Scotland, especially the west coast of the mainland, which display relative sea level fall resulting from glacial induced isostacy outstripping eustacy (Gordon & Sutherland, 1993). The Western Isles have less pronounced isostacy due to the smaller ice volumes that loaded the land and hence the sea level has risen quicker than the land. Ritchie (1985) investigated 21 sites in the 'inter-tidal' zone (as defined by Ashmore, 1994) that led him to conclude that submergence has been dominant in the Uists since the Post Glacial period. It is reasonable to expect a similar pattern in Lewis. He suggested that the rise may have been in the order of 5m from the onset of the Holocene to approximately 5100 BP and a steady rise since then of up to 2m. This would seriously affect the coastal settlement through submergence of relatively fertile land and the associated archaeology. This sea level rise is also implicit in the activation of the development of machair.

Machair is one of the most distinctive landform types of the Western Isles and has been the focus of crofting agriculture in recent centuries (Owen *et al.*, 1996). W Ritchie (1976) attempted to construct a detailed description of the machair plain based on a number of different criteria, principally the shell-rich derivation of the matrix and the relatively low number of vascular plants (100-150) compared to larger and more varied dune systems in other parts of Britain, with 400-500 different species. Curtis (1991) expanded this description to include the associated strandline, dune, machair grassland, coastal lochs, marshes and saltmarshes in the overall 'machair system', elements of which can be found throughout the Western Isles. Ritchie (1979) proposed a model for the origin and development of the three broad groups of machair surfaces existing today. These include 1) hilly, hillside or steeply sloping (e.g. Cnip headland and Bostadh in West Lewis) 2) plain surfaces with higher areas on the landward side (machair plain in South Uist) and 3) generally level or slightly sloping plain surfaces terminating in marsh/loch/rock or till covered surface (Traigh na Beirgh in West Lewis). The model was simple and involved large amounts of mineral sand left over from the last deglaciation and shell fragments driven inshore by the oceanic climate coupled with sea level rise over the past 7-8000 years. He estimated the major accretion phase would have started as early as 3750 cal BC and Gilbertson *et al.* (1995a, 1996c) have dated a number of palaeosols at the base of machair sequences that confirm that the fourth millennium BC saw the first concerted phase of machair development. They also suggested that the development of machair was characterised by long periods of stability interspersed with shorter phases of active erosion and deposition resulting in distinct laminations in the machair stratigraphy that they described as 'machair stratification'. Inherent within Ritchie's model (1979) was the assumption that the volume of sand in the system remained relatively constant, a requirement of the model that is facilitated by the topographic control of many of the machair systems throughout the Western Isles. This control usually takes the form of hills or mountains and the interface of the machair and the hillslope soils was seen as an extremely fertile area in the recent past, as the calcareous sand mixed with the more peaty and organic hill slope soil created a soil approximating to a loam (Smith, 1994).

This soil amended by human activity in the Medieval and post-Medieval periods is part of a mosaic of amended soils that exist in many coastal areas, known as the 'brownlands' (Boyd & Boyd, 1990). The main mechanism for this amendment is through the construction and sustained input over a number of centuries of material, such as seaweed and sand, in to the rigs and spade dug lazy beds that cover many coastal areas across the Western Isles. This not only provided drainage for the soil matrix in the rigs but also enriched the basic nutrient budget of the soil matrix (Smith, 1994; Hudson, 1994). It is difficult to estimate the extent of the brownland zones within the first millennia BC and AD due to the rarity of field systems recovered and the truncation and soil redeposition inherent within the creation of the Medieval and post-Medieval rigs.

The most extensive landscape zones in the Western Isles are the various areas of blanket peat, moorland and bog that cover the interior of most of the main islands (Figure 2.1). These areas are known locally as the 'blacklands' and are used for little more than rough grazing and peat cutting in the present day. Transhumance was practised in the recent past with the archaeological legacy of many hundreds of shielings throughout the islands. The development of the 'blacklands' is the result of a complex interplay of climatic, pedogenic and anthropogenic factors and also local changes in the annual water table and evapotranspiration budget (Moore, 1993). The timing and extent of this blackland expansion is described below with particular reference to the vegetation history provided by pollen diagrams during the first millennia BC and AD. The evidence for palaeoclimatic reconstruction is examined first.

2.4 Palaeoclimate of study area

The integration of the palaeoclimatic and archaeological record is notoriously difficult. Problems basically stem from the discontinuous nature of both data sets, the limited accuracy of the dating techniques applied and the difficulty in matching the chronologies produced (Meese *et al.*, 1994). Despite this, palaeoclimatic reconstruction is very important to understanding the human / plant interaction as climate dictates the limits of most aspects of plant growth. The major advances in palaeoclimatic reconstruction have taken place over the past 15 years or so. Prior to this, the general scheme of climate change in Britain was based on the Blytt-Sernander model (Blytt, 1876; Sernander, 1908), originally based on peat stratigraphy and palynological profiles from across north west Europe (Table 2.2). The transition between the warm and dry sub-Boreal and the cool and wet sub-Atlantic zones within the second millennium BC and the first half of the first millennium BC was used by various researchers (cf. Parry, 1978; Burgess 1980, 238-40; Smith *et al.*, 1981), in tandem with surveys of extensive tracts of abandoned Late Bronze Age settlements and field systems, to invoke a retreat from marginal areas and uplands within Britain. This so-called Late Bronze Age / Early Iron Age climatic deterioration was followed by a relatively stable period of this wetter and cooler climate until the beginning of the Medieval Warm Period at the end of the first millennium AD (Lamb 1977, 418-20).

The Blytt-Sernander model was questioned due to increased appreciation of the complexities of ombrotrophic bog wetness and vegetation history in north west Europe. The model began to fall out of use in the 1980s with the appearance of the new evidence of the ice and sea core data from the North Atlantic and Greenland ice shelf. Both these sets of profiles provided various proxies of high resolution palaeoenvironmental data that were invoked to reconstruct climatic change, initially over the glacial/interglacial timespan. The initial thoughts on Holocene climate presented a picture of remarkable stability (Grootes *et al.*, 1993). This view was challenged by more detailed close-interval sampling of the various cores that started to show various sudden warm and cold events occurring throughout the Holocene (cf. Meese *et al.*, 1994; O'Brien *et al.*, 1995). One of the most important recent advances is the evidence of abrupt climate shifts based on cool, ice-bearing waters from the north of Iceland advected as far south as the latitude of Britain, coupled with changed atmospheric circulation over Greenland (Bond *et al.*, 1997). The existence of the ice rafting was based on lithic grain concentrations and petrologic tracers, such as tephra shards and haematite stained grains, from well-dated sea-bed cores between Iceland and Greenland and approximately 300 km off the west coast of Ireland. Peaks were noted at approximately 1400 and 2800 cal BP as part of a proposed cyclicity of ice rafting of 1470±500 years throughout the Holocene. These abrupt events, such as the ice-rafting, become less synchronous when comparing the various cores from Greenland and the North Atlantic, with some events only being recorded by a certain proxy or within a certain core. Therefore as the Holocene progressed, environmental change increasingly occurred on a regional basis (O'Brien *et al.* 1995). One of the challenges of modern palaeoclimatic research is linking these North Atlantic scale proxies to the regional, terrestrial proxies that are more informative in terms of human response to climate change.

When attempting to integrate these differing scale proxies a rather confusing and contradictory picture emerges, reflecting the fact that palaeoclimate studies are in a state of flux. The main problems are matching the myriad number of proxies and events, especially given the problems of inaccurate or wide dating resolution and potential discontinuities in the record (Meese *et al.*, 1994). Chambers *et al.* (1997) used the degree of humification of organic material as a proxy for surface wetness of an upland blanket mire in Talla Moss, southern Scotland that recorded pronounced wet shifts in climate at approximately 3070, 2256 and 1700 cal BP. A series of humification profiles centred on Loch nan Cnamh and Guinnerso East Moor (denoted GEM) in West Lewis (see Figure 2.3 for location of sites) have been produced using a revised procedure, with preliminary dating control provided by tephrochronology (Coles, in prep.). Two of the longest profiles that cover the period of the first millennia BC and AD are illustrated in Figure 2.4. In general, the drier the surface of the bog, the greater the degree to which the organic material is broken down and humified. Therefore the oscillations within the two profiles basically show variation between increased wetness and dryness.

By integrating the North Atlantic and regional scale proxies a preliminary and rather general summary of the climate in the Western Isles during the first millennia AD and BC can be proposed. The Bronze Age / Early Iron Age climatic deterioration marks the beginning of the first millennium BC with worsening climate, in terms of wetness, storminess and temperature shown in both the North Atlantic and regional humification models. A period of dryer conditions then starts at approximately 500 cal BC, peaking at approximately 100 cal BC on comparison with the Glen Garry tephra isochrone. The climate then becomes wetter again in the Western Isles with a possible peak of wetness corresponding with the 7th century cal AD ice rafting episode. The final centuries of the first millennium AD are then characterised by the increased dryness of the Medieval Warming Period. It is likely that the weather changes associated with dramatic events, such as the ice rafting, would have profound effects on the human population in the marginal areas of the Atlantic seaboard, such as the Western Isles. It is likely that the basic subsistence economy would have inherent survival mechanisms within it that would buffer the effects of these dramatic climatic events. For example, crop failure resulting from very wet or cold summers could be offset by diversifying the economic base or creating a surplus for long-term storage to mitigate against such occurrences. The presence or development of such buffer mechanisms will be explored in more detail in Chapter 8. The vegetation history of the islands will now be examined, a mosaic of habitats and plant communities that responds to climatic as well as human impacts on the environment.

2.5 Vegetation history

2.5.1 Development of the debate

The Holocene vegetation history of the Western Isles is one of the more controversial and hotly debated topics within Scottish palaeoecology (Dickson & Dickson 2000, 64-7). Many researchers have undertaken detailed research over the past 25 years, with over 20 pollen sequences already published from the island chain. The common thread linking all of these sequences is the basic desire to assess the development of the open landscape, with particular reference to the scale and nature of possible woodland cover. Three basic categories of evidence have been used and the locations and types of evidence from each of the palaeoecological sites are shown in Figure 2.3. The main line of evidence is from the extraction of pollen from lochs or blanket bog sequences, with the waterlogged and acidic conditions of both sediment types ideal for pollen preservation. These conditions also allow the preservation of uncarbonised plant macrofossils, such as tree stumps and leaf litter within the peat sequences that have also been used to reconstruct past vegetation communities at specific points in the landscape. A few carbonised plant macrofossil assemblages have also been recovered from archaeological sites from the Neolithic through to the post-Medieval that provide direct evidence of the anthropogenic exploitation of various plant communities. Indirect evidence for vegetation reconstruction is also available from alternative proxy records, such as molluscan remains at the Beaker settlement of Northton in Harris and insect analysis of waterlogged deposits at the Neolithic site of Eilean Domhnuil in North Uist (Warsop, 2000).

The first phase of investigation between 1906 and the 1970's was characterised by the observations of tree stumps largely of birch within cut peat banks or exposed peat sections on the coast or loch edges (Lewis, 1906, 1907; Beveridge, 1926; Ritchie, 1966; von Weymarn, 1974; Angus, 1987). This established that birch woodland existed at certain spots in the landscape prior to the large scale expansion of blanket peat. However, the few early pollen sequences from Barra (Blackburn, 1946), Benbecula (Ritchie, 1966) and a number of sites in Lewis (Erdtman, 1924), suggested that woodland was not a significant component within the landscape due to the low levels of arboreal pollen. This impression of a "forestless zone" was reinforced by the first well-dated pollen sequence covering the Late-glacial, post-glacial and Holocene periods from Little Loch Roag, in West Lewis (Birks & Madsen, 1979). The arboreal pollen never exceeded 10% and therefore led the analysts to state that the regional aspect of the Western Isles throughout the Holocene was dominated by an open landscape. This comprised grassland and heath with occasional stands of birch (*Betula* sp.) and hazel (*Corylus* sp.). Increased moorland expansion in the latter half of the Holocene was also indicated.

One of the first modern analyses to challenge this picture was the molluscan assemblage analysed by Evans (1971) from the Neolithic and Beaker middens at Northton (Simpson, 1976). It was claimed that the presence of woodland was indicated at each of these phases by the presence of shade loving snails, the Chrysalis snail (*Lauria cylindracea* L.), the Garlic glass snail (*Oxychilus alliarus* L.) and the Long-toothed herald snail (*Carychium tridentatum* L.). However, an element of caution must be exercised in the interpretation of the habitat information used by Evans as it was based on modern faunal surveys of limestone and chalk in Southern England. Secondly, the first two snail species were found to be common in a wide range of habitats in a later faunal survey of machair (Kerney, 1976). Also, detailed information on the context of extraction and taphonomy of the molluscan assemblage is still awaited from the publication of the site. Past research has shown that shade-loving species traditionally used to indicate woodland are common throughout the damp and dark parts of machair settlements, such as the wall fills (Carter, pers comm). Less contentious evidence of the presence of a significant woodland component was presented by Wilkins' (1984) description and sampling of over forty macrofossil remains of Scots pine (*Pinus sylvestris* L.), birch and willow (*Salix* sp.) in the lower portions of peat profiles across Lewis. Radiocarbon dating of 11 tree stumps suggested that the willow dated to between 9200 to 8500 BP, the birch between 8000 and 5000 BP and the pine dated from 4800 - 3900 BP. A further forty sites with woodland macrofossils from Lewis to South Uist were also identified by Fossitt (1996). The first palynological evidence of significant woodland came from the composite pollen diagram from peat bank profiles at Tob nan Leobag (Bohncke, 1988), a small peninsula with evidence of Bronze Age field systems, jutting out into the sea loch near to the Calanais stones. Early to mid Holocene arboreal pollen levels ranged between 30 and 80 %, with high percentages of birch pollen, with some hazel, Rowan (*Sorbus aucuparia* L.) and willow. A mid Holocene peak between 5500 and 4500 cal BP was noted, indicating an open type of birch woodland between the Mesolithic / Neolithic transition in the area. Both Wilkins (1984) and Bohncke (1988) suggested that the assertions by Birks & Madsen (1979) that the Western Isles were predominantly open landscapes throughout the Holocene was at odds with the evidence of their research. Birks (1994) responded by suggesting that there was no disparity between the data from Little Loch Roag data and Tob nan Leobag as "both can indicate small areas of scrub in local, sheltered situations and a predominantly treeless regional vegetation".

2.5.2 Problems and resolution of interpretation

Two competing research hypotheses on the nature and extent of Holocene woodland therefore existed, attracting further analysis in the form of detailed palynological sampling, including Doctoral research projects in South Uist by Fossitt (1990) and Brayshay (1992) and in West Lewis by Lomax (1997). As a result, over 20 pollen diagrams now exist for the Western Isles in various stages and states of publication. However, these diagrams vary in their chronological range of coverage. For example, only a small proportion of these diagrams covers the entire Holocene, with truncation of the later periods the chief cause. Also, variable levels of dating control have been used, with some diagrams only utilising a few of bulk radiocarbon dates and some with none at all. Direct comparison with archaeological periods and sites is also complicated by the lack of calibration for the radiocarbon dates within all of the diagrams.

Further problems in interpreting pollen data from the Western Isles stem from taphonomic complexity. The first problem involves the movement and redeposition of peat within a mire or blanket bog. Close interval dating of peat within a valley mire sequence at Borve in Barra revealed older peat overlying younger peat, interpreted as being the result of peat creep or landslides (Ashmore *et al.*, 2000). This could be a serious problem for pollen diagrams from peat columns, especially the composite profile from the three peat banks at Tob nan Leobag. Also, some of the profiles have relatively poor dating control and so redeposition is unlikely to be spotted at these sites as several close interval AMS dates would be needed throughout a profile to identify this phenomenon. The direct pollen taphonomy in an Atlantic environment also presents an extra interpretative complication. Pollen traps set in and around Allt Volagir wood and the Northbay plantation in Barra indicated that the modern tree pollen falls to background levels only a few tens of metres from the edge of the wood (Fossitt, 1994; Gearey & Gilbertson, 1997). Therefore, past woodland will only be detected if a sampling point is within or immediately adjacent to the wood at any given time in the pollen sequence.

Because of these problems, only four relatively simple questions have been posed for each diagram including a) identifying periods of significant tree cover and the timing of major deforestation, if any

b) the timing of significant expansion of moorland c) the timing of significant arable and grassland/pastoral component d) and general nature of landscape during first millennia AD and BC. The pollen evidence will be discussed in terms of the two main island groups, i.e. Lewis and the Uists and Barra.

2.5.3 The evidence from Lewis

Eight pollen diagrams are used in this brief overview of vegetation history running from the Late glacial through to the Late Holocene. The evidence will be discussed in terms of broad chronological changes with particular reference to the role of human impact in the long-term vegetation history and the landscape of the first millennia BC and AD. Seven of the eight diagrams come from West Lewis (see Figure 2.3) within the immediate confines of the study area. The evidence includes almost complete sequences from lochs and mires at Little Loch Roag (Birks & Madsen, 1979), Loch Bharabhat (Edwards *et al*., 1994; Lomax & Edwards, 2000), Loch Builaval Beag (Fossitt, 1996), Loch Ruadh Guinnerso (Flitcroft, 1997) and Loch na Beinne Bige (Edwards *et al*., 1994). Shorter sequences came from peat sections adjacent to buried field walls at Tob nan Leobag near Calanais (Bohncke, 1988), Sheshader on the east coast (Newell, 1988) and the later prehistoric infilling of the machair slack of Loch na Beirgh (Lomax, 1997). Summary diagrams of key profiles are shown in Figures 2.5, 4.3, 4.4, 4.13 and 4.21. All of the dates are expressed as uncalibrated radiocarbon years before 1950 (C^{14} yr BP).

2.5.4 Late Devensian vegetation of Lewis (c. 14000-10000 BP)

Evidence for Late Devensian vegetation change comes from the base of the profiles at Loch Bharabhat and Loch na Beinne Bige. Both show similar environmental conditions with the vegetation reflecting the initial warming of the Windermere interstadial (14000-11500 BP) followed by the short lived return to tundra environments during the Loch Lomond stadial (11500-10500 BP). The first plants to colonise the tundra were dwarf willow, grasses (Poaceae undiff.), sedges (Cypreceae undiff.), docks (*Rumex* spp.), some buttercups (Ranunculaceae undiff.), daises (Asteraceae undiff.) and mosses. An extensive Crowberry (*Empetrum nigrum* L.) heath developed with increased warming, which included mugwort (*Artemesia* spp.), meadowsweet (*Filipendula* spp.) and some possible birch shrubs. However, despite the presence of birch the landscape would have been very open, especially with the return of glacial conditions with the Loch Lomond stadial when the vegetation reverted back to the conditions following the initial retreat of the ice.

2.5.5 Early to mid Holocene vegetation of Lewis (c. 10000-5000 BP)

The immediate post-glacial period would have seen a very rapid rise in temperature marking the beginning of the Holocene. The crowberry heath would have been replaced by a more mixed tall herb and grass vegetation with the introduction of Juniper (*Juniperus communis* L.) and tree birch.

Woodland development was not spatially or temporally controlled when comparing the various pollen profiles. For example, at Loch Bharabhat, Loch na Beinne Bige and Loch Builaval Beag woodland cover became increasingly dense and diverse with the appearance of hazel and some pine, oak (*Quercus* sp.), elm (*Ulmus* sp.) and alder (*Alnus* sp.). However, some sites, such as Loch Ruadh Guinnerso and Little Loch Roag, remained open with little significant arboreal pollen, except for some birch representing very localised stands. Also, there is evidence from Tob nan Leobag and Loch Builaval Beag of variation in the woodland cover that has been tentatively attributed to human clearance, through possible fire ecology, during the early to mid Holocene (Edwards, 1996; Edwards *et al.*, 1995). All of the diagrams display the first signs of heath and moorland development with the appearance of Ling and other heathers (*Erica* spp.) between 9000 and 8000 BP.

2.5.6 Neolithic to Late Bronze Age vegetation of Lewis (c. 5000-3000 BP)

The landscape confronting the first agriculturists would have been a mosaic of tall herb grassland, *Calluna* heath, bog and birch-hazel woodland in the more sheltered areas. A number of important events took place during the sixth millennium BP. Firstly, evidence of significant woodland clearance, presumably as a result of human action, is recorded from all of the sites with previous woodland cover. However, for the following 1500 years from the Neolithic through to the early Bronze Age this woodland cover following the initial deforestation at Loch Bharabhat, Tob nan Leobag and Loch an Beinne Bige varied in density, suggesting possible controlled regeneration as part of the wider economic strategy of the human population. Further evidence of human activity can be seen with the first appearance of cereal type pollen in the Neolithic at Tob nan Leobag. However, caution must be exercised when identifying cereal pollen in Atlantic oceanic climates as maritime grasses have very similar pollen morphologies to those of cereals (Anderson, 1978). This explains the occurrence of 'cereal type' pollen at levels just after 7600 BP at Loch Builaval Beag, rather than pre-Neolithic cereal use. Further arable and pastoral indicators are apparent from the sixth millennium BP onwards in most of the diagrams including Ribwort plantain (*Plantago lanceolata* L.), tormentil (*Potentilla* spp.), docks (*Rumex* spp.), nettles (*Urtica* spp.) and members of the Ranunculaceae and Brassicaceae families. This spread of agricultural land becomes more apparent in the early to mid Bronze Age and is accompanied by a further major woodland clearance at Loch Bharabhat, Tob nan Leobag and Loch an Beinne Bige. Throughout the Neolithic and Bronze Age moorland was also expanding, reflected by the gradual but perceptible rise of Ling, heather and sedge pollen. This expansion is presumably a function of climate, topography, natural pedogenesis and the woodland clearance and human activity that would have exposed the relatively fragile soils to erosion, waterlogging and leaching.

2.5.7 Iron Age to early Medieval vegetation of Lewis (c. 3000-1200 BP)

At the beginning of the time period covered within this study nearly all of the woodland had already disappeared and the predominantly open landscape would have been a mix of acid grassland, heathland and bog with smaller areas of cultivation and tall herb pasture. The general configuration of this landscape essentially remained the same up to the present day. Changes in the vegetation are not as pronounced as previous periods but again these changes are not chronologically or spatially concurrent. For example, at Loch Bharabhat from approximately 2800 BP a number of disturbed ground and erosion indicators, including minerogenic inwash and aquatic taxa such as the quillworts (*Isoetes* sp.), increase markedly showing disturbance of the soil in the surrounding catchment, presumably due to agriculture and the worsening climate. By approximately 2000 BP these erosion indicators decrease indicating stability in the soil system, which may relate to less activity in the area. Conversely, from this time a period of disturbance accompanied by the first appearance of significant numbers of cereal grain and other arable and pastoral indicators is recorded at Little Loch Roag. One of the constants of this period is the dominance of heath and moorland taxa within the diagrams and this is accompanied by a number of microscopic charcoal peaks that may relate to deliberate management of the heath, through a form of muirbuin (Edwards *et al.*, 1995).

2.5.8 The evidence from the Uists, Barra and Vatersay

15 modern pollen profiles with radiocarbon dating control have been produced from North Uist down to Barra (Figure 2.3). Two short profiles were taken from peat sections associated with prehistoric field systems in North Uist at Loch Portain (Mills *et al.*, 1994) and Bharpa Carinish (Crone, 1993). Late glacial through to late Holocene profiles from South Uist include Kildonan Glen, Loch Hellisdale (Brayshay & Edwards, 1996), Loch Lang (Bennett *et al.*, 1990), Loch an t-Sil, Reineval, North Locheynort, Loch Airigh na h-Aon Oidhche (Edwards & Whittington, 1994) and Loch a'Phuinnd (Fossitt, 1996). A shorter profile from an early to mid Holocene peat deposit was also recovered from Peninerine (Edwards & Whittington, 1994). Late glacial through to Late Holocene profiles from Barra include Lochan na Cartach (Brayshay & Edwards, 1996), Glen Bretadale (Gilbertson *et al.*, 1995b) and Borve mire (Ashmore *et al.*, 2000), with a sequence of inter-tidal Late glacial / early Holocene peats and clays at Port Caol (Brayshay & Edwards, 1996). Two short profiles from Old Ground Surfaces under two kerb cairns on South Vatersay (Edwards & Craigie, 2000a & 2000b) complete the data set of this lower island group. Summary profiles of some key sites are shown in Figure 2.6. One of the problems with the data set is the lack of sensitivity in spotting the development of the machair vegetation and plain of South Uist in particular. The nature of pollen preservation demands that samples must be taken from permanently waterlogged, acid conditions that are the opposite to those that exist within or immediately adjacent to the machair. Therefore, because of the largely extra-local taphonomy of the pollen within the Western Isles (Fossitt, 1994, 1996; Gearey & Gilbertson, 1997) most of the vegetation reconstruction will be within a few hundred metres of the pollen site, whether blanket bog or loch.

2.5.9 Late Devensian vegetation of the Uists and Barra (c. 14000-10000 BP)

All of the diagrams that cover this period suggest an open landscape similar in character to that suggested for Lewis. However, unlike the Lewis profiles, such as Loch Bharabhat, it is not possible to differentiate between the Windermere interstadial and Loch Lomond stadial. Again, crowberry heath is the most notable landscape unit with mugwort, dwarf birch and willow, Juniper and various grasses. Slightly different proportions of these various taxa can be seen between the easterly and westerly sites, a function of the sensitivity and possible microclimate between the positions (Brayshay & Edwards, 1996).

2.5.10 Early to mid Holocene vegetation of Uists and Barra (c. 10000-5000 BP)

The climatic amelioration at the beginning of the Holocene marks the replacement of the marginal heath and grassland with a more diverse mosaic of tall herb grassland, moorland, bog and woodland communities. Again, this landscape development is not spatially or chronologically simultaneous. For example, the increase in birch at the beginning of the Holocene occurs over a period of 1000 years at the 13 sites. In general most of the profiles have significant proportions of arboreal pollen during this period, with some profiles such as Lochan na Cartach, Loch Hellisdale and Kildonan Glen displaying over 80% AP. The woodland was dominated by birch with some hazel and some diagrams, such as Loch Lang, also containing significant proportions of other tree species, such as oak, elm and even ash (*Fraxinus* sp.). Again, Ling and other heath plants appear in most profiles early, at approximately 9500 - 8000 BP, and increase in proportion throughout the Holocene. Possible Mesolithic fire ecology of both the woodland and heath can be inferred from the presence of microcharcoal peaks associated with reductions of woodland cover (e.g. Loch an t-Sil at approximately 8040-7910 BP) and small increases in heathland taxa (e.g. Loch Lang from approximately 9500 BP).

2.5.11 Neolithic to Late Bronze Age vegetation of Uists and Barra (c. 5000-3000 BP)

The decline of the woodland during the mid to late Holocene was not a simultaneous process. For example, at Loch an t-Sil the birch-hazel woodland was gradually replaced by grasses (Poaceae undiff.), sedges (*Carex* spp.) and heath taxa from the 8th millennium BP but the major deforestation at some sites, such as Lochan na Cartach occurred three millennia later. Clearly, a range of processes interacted to create this replacement of the woodland cover. Most of the sites display a gradual replacement, rather than the clear deforestation events shown by some of the Lewis profiles, which may imply that climate and pedogenesis rather than human action were the main forcing mechanisms in the southern island group. However, there is widespread microcharcoal evidence for possible fire-heathland management from the Neolithic to the present day, which may account in part for the inexorable spread of blanket peat and bog. Evidence for agriculture, including cereal pollen and disturbed ground and weed taxa, begins to appear from the Neolithic but the evidence is not as marked as some of the profiles from Lewis.

2.5.12 Iron Age to early Medieval vegetation of Uists and Barra (c. 3000 - 1200)

The landscape at the beginning of the first millennium BC would have been similar to that in Lewis, with a predominantly open aspect of largely heath and blanket bog with some areas of cultivation, tall herb pasture. Woodland cover would only have been possible in sheltered areas inaccessible to animals, in either inaccessible places such as cliffs or areas deliberately cordoned off by humans. The development of the machair systems, especially the machair plain of western South Uist, would have been well established. The configuration of this landscape remained essentially the same up to the present day.

2.5.13 Comparative summary of the vegetation history of the Western Isles

When comparing the two island groups a number of similarities and differences are apparent. Evidence of the Late Devensian is now emerging from throughout the island chain, demonstrating the tundra nature of the vegetation. However, the differentiation between the Windermere interstadial and the Loch Lomond stadial can only be seen in two profiles in Lewis. The early Holocene amelioration saw a varied mosaic of habitats developing with a possible north / south divide in woodland cover. For example, the Uists and Barra in general show woodland cover in most places whereas Lewis is much more open with only certain sheltered areas, such as Calanais and Loch Bharabhat, supporting woodland. The actual woodland cover is dominated by birch with some hazel, willow and pine though some of the southern sites and Loch Bharabhat in Lewis also have significant proportions of more mixed forest taxa, such as oak, elm and even ash. Many of the longer profiles show initial signs of heathland between 9500 and 8000 BP and the encroachment of blanket bog is seen throughout the Holocene, with both gradual and sharp increases in heath taxa. These increases are intimately linked to climatic, pedogenic and anthropogenic processes, with possible fire-heathland management becoming increasingly marked in the later millennia. The woodland replacement by arable and pasture land, grassland and heath is non-synchronous over the island chain and again displays both gradual replacement and also marked deforestation events. The first signs of arable cultivation are seen in the early Neolithic in certain profiles, such as Tob nan Leobag, but again the first appearance of pollen indicators is not concurrent chronologically or spatially, with some profiles only registering background level of cereal type pollen in the last millennium BP. A number of profiles, including Loch Lang in South Uist and Loch a'Phuinnd and Little Loch Roag, display significant arable activity within their immediate catchments in the mid to late first millennium AD, which may be a factor or arable intensification and expansion into more marginal areas. By the beginning of the first millennium BC the landscape of the Western Isles would have been almost totally open, dominated by heath and blanket bog with smaller areas of agricultural land, tall herb grassland and machair and only very isolated stands of trees. The regional scale configuration of this vegetation landscape essentially remained the same up to the present day. Specific plant communities and small-scale changes in the pollen profiles near to the archaeological sites sampled as part of this study are highlighted during discussions within appropriate sections. These include the profiles from Loch Bharabhat and Loch na Beirgh for the sites sampled on the Bhaltos peninsula (Section 4.4), Loch Ruadh Guinnerso for the cellular building at Guinnerso (Section 4.13) and Tob nan Leobag and Loch na Beinne Bige that are a few kilometres from Calanais kerb Cairn (Section 4.8).

2.5.14 The archaeobotanical assemblages

The large number of pollen profiles across the Western Isles is in stark contrast to the small number of published archaeobotanical assemblages from archaeological sites in the island chain. At the time of the initial sampling of the sites that comprise this study (1995), only three assemblages were published, with a further nine assemblages either published after 1995 or that have undergone analysis but still await publication of the site. The published reports include carbonised plant macrofossils from a few Beaker samples from the fill of cultivation furrows at Rosinish in Benbecula (Shephard & Tuckwell, 1977), 23 samples from the Neolithic sub peat activity at Bharpa Carinish, North Uist (Boardman, 1993; Crone, 1993), 10 samples from the Neolithic and Beaker structure at Allt Chrisal, Barra (Boardman, 1995a), over 135 samples from the various Iron Age phases at the complex Atlantic roundhouse at Dun Vulan (Smith, 1999; Taylor, 1999) and seven samples from the Atlantic roundhouse and wheelhouse structures at Alt Chrisal T17, Barra (Smith, 2000). The unpublished reports include 31 samples from a rectilinear structure of Norse Age at Barvas machair, Lewis (Dickson, unpubl.), over 350 samples from the Iron Age structures and middens at Baleshare and Hornish Point in North Uist (Jones, unpubl.), 22 samples from the Iron Age wheelhouse at Kildonan, South Uist (Grinter & Valamonti, unpubl.), 40 samples from the Neolithic islet settlement at Eilean Domhnuill, North Uist (Grinter, unpubl.; Crone, unpubl.), 10 samples from a Neolithic chambered cairn at Geirisclett, North Uist (Church, unpubl. a) and 23 samples from the Bronze Age burnt mound and associated cellular building at Ceann nan Clachan, North Uist (Church, unpubl. b). Figure 2.3 shows the location of the sites and Table 2.3 outlines the main details of each of the assemblages. The main findings from each site have been integrated to form the following chronological narrative of the use of plants by humans from the Neolithic to Norse period.

The Neolithic and Beaker material comes from domestic structures and middens at Allt Christal, Bharpa Carinish, Rosinish and Eilean Domhnuill, with small amounts of material associated with funerary monuments at Geirisclett and Ceann nan Clachan. The principal cereal grains recovered were six-row naked barley (*Hordeum vulgare* var. *nudum* L.), with smaller proportions of emmer wheat (*Triticum dicoccum* L.) at Bharpa Carinish and Rosinish (see Table 2.3). A few grains of bread wheat (*Triticum aestivo-compactum* L.) were also recovered from Eilean Domhnuill and Allt Chrisal. Most of the cereal remains consisted of cereal grains, with little chaff and some wild species that could be interpreted as weeds of an arable crop due to their ecological affinities. The weed seeds that have been recovered, including the knotgrasses (*Polygonum / Persicaria* spp.), docks (*Rumex* spp.), goosefoots (*Chenopodium* spp.), oraches (*Atriplex* spp.), brassicas and charlocks (*Brassica / Sinapis* spp.) are typical of the unspecialised weed floras associated with Neolithic crops (Greig, 1991). Nuts, fruits and berries from various edible plants were also gathered, notably hazel nuts (*Corylus avellana* L.) with some Crab apples (*Malus sylvestris* L.) and a few seeds of Bramble (*Rubus fruticosus* L.), Wild strawberry (*Fragaria vesca* L.), Bearberry (*Arctostaphylos uva-ursi* (L.) Sprengel), Cowberry (*Vaccinium vitis-idaea* L.) and Bilberry (*Vaccinum myrtillus* L.). Various heather species, notably

Ling (*Calluna vulgaris* L.), bracken (*Pteridium aquilinum* L.) and sedges (*Carex* spp.) were present in the larger assemblages that may have been gathered for fodder, furnishings, weaving and thatching. Other habitats, such as bogs, streams and lochs were also indicated by the presence of water-loving plants, such as rushes (*Juncus* spp.). Clearly, a range of habitats present in the landscape from the pollen evidence were exploited at various points across the Western Isles.

A variety of genera of charcoal, and uncarbonised wood from Eilean Domhnuill, were recovered from most of the sites (see Table 2.3). The most abundant species, birch and hazel, reflect the main elements of the woodland indicated by the pollen diagrams. Ling heather was also frequently recovered. The less frequent species include alder, pine, willow, Pomoideae and Sloe types that were all present in the woodland pollen taxa, admittedly in low concentrations. None of the trees associated with the more mixed woodland during the mid Holocene, such as oak, elm or ash, were recovered from the sites indicating either the scarcity and possible removal of this type of woodland by the mid to Late Neolithic or the selective gathering of certain types of trees. Larch (*Larix* sp.) fragments with shipworm boreholes was also recovered from Eilean Domhnuill that would have been collected as driftwood.

The absence of Bronze Age domestic assemblages stems from the lack of such structures in the archaeological record but this situation is reversed in the later periods with all of the Iron Age assemblages stemming from sites of a domestic nature. A relatively large number of samples were taken from Baleshare, Hornish Point, Kildonan III and Dun Vulan covering a number of different structural types and phases. The assemblages are discussed here as single blocks, due to the vagaries of dating in Atlantic Scotland (see Section 4.2) and the preliminary nature of analysis at this stage. More detailed comparisons, both in terms of chronological and quantitative resolution, will be undertaken with the assemblages from this study in Chapter 8.

The principal cereal type during the Mid and Late Iron Age was six-row hulled barley, with occasional grains of naked barley, emmer wheat, oat (*Avena* sp.) and rye (*Secale cereale* L.) that were probably weeds of cultivation. Again the cereal remains are predominantly grains with very few chaff remains. The wild species indicated a variety of habitats ranging from heath, moor and mire through to light free draining machair sands. Clearly, this admixture of habitats between and within samples was a function of the archaeobotanical taphonomy, a subject explored in detail in Chapter 5. Very few gathered nuts and berries were recovered from these later sites, which may indicate a decrease in the importance of these plant products from earlier periods. This may be a function of recovery, changing attitudes to plant use or a lack of resource. Other plants, such as heather, bracken, sedges and seaweed were clearly still being gathered for a variety of domestic purposes. The presence and degree of management of any remaining woodland in the first millennia BC and AD is very hard to assess as no charcoal from the Iron Age sites was systematically analysed, though wood-working debris from a waterlogged Early Iron Age context at Dun Vulan contained hazel, alder and larch (*Larix* sp.) chippings. Again, the larch would have been collected as driftwood, attested by the presence of shipworm boreholes, and one of the hazel pieces displayed the characteristic disarticulation heel of coppicing, known as a coppiced heel. A single roundwood fragment of Purging buckthorn (*Rhamnus catharticus* L.) was also discovered in this waterlogged deposit. This species would have grown in wet woods in chalk or limestone areas, and is unlikely to have been used as timber and therefore may point to a less prosaic and possibly ritual use of this plant in the Iron Age (Taylor, 1999).

Only a single assemblage of Norse date is available for analysis, though the SEARCH project in South Uist is currently engaged in a number of Norse period excavations, notably Bornais (Sharples, 2000, 2001). The assemblage from Barvas machair in Lewis again consisted of six-row hulled barley but also contained a significant proportion of oat, some flax seeds (*Linum usitatissimum* L.) and a single Common vetch (*Vicia sativa* ssp. *augustifolia* L. Gaud.). Very little charcoal was recovered and no gathered nuts and berries were found.

In summary, the archaeobotanical remains recovered from the archaeological sites reflect use of plants from a variety of habitats including those that were directly managed by humans, such as arable fields, areas that may have experienced limited management, such as moorland and woodland, and 'natural' habitats, such as lochs, coastlines and cliffs. A summary of the state of knowledge for the archaeology of the first millennia BC and AD will now be presented. The key research themes that can be addressed from the range of plant material on archaeological sites will then be highlighted with regard to all the palaeoenvironmental and archaeological background information in section 2.7.

2.6 Later prehistoric archaeology

The Later prehistoric and Norse archaeology of Atlantic Scotland contains some of the best-preserved cultural resources in Britain. This section will first outline a number of practical aspects of working in the region before turning to the settlement pattern of the first millennia BC and AD. The evidence for subsistence and land use will then be reviewed for the Western Isles before outlining the basic artefactual toolkits found on the sites. The current debates on social structure will then be outlined.

2.6.1 Practical aspects of Atlantic Scottish archaeology

One of the outstanding characteristics of Atlantic Scotland is its excellent structural and stratigraphic preservation. This preservation is a function of the stone built structures protecting the stratigraphy as well as the lack of post-Industrial intensive agriculture that has truncated much of the archaeological resource in Lowland Britain. The very common occurrence of *in situ* material is also very different to the sites characterised by negative feature in many lowland areas. Indeed, the stratigraphic sequences in multi-period sites in Atlantic Scotland have been likened to tell-formation and midden accumulation associated with Medieval urban sites (Nicholson & Dockrill, 1998). This allows research questions to be posed that address the deposition of cultural material and activities in the structures (cf. Parker-Pearson & Sharples, 1999; Smith *et al.*, 2001), although an appreciation of site formation processes and abandonment is needed (cf. LaMotta & Schiffer, 1999). In terms of the recovery of plant macrofossils, this means that there are a large range of generic context types, including hearth material, floor levels, ash spreads and middens, which can be sampled and related to specific phases of the life history of the structure. This seemingly excellent potential for dating the structures and investigating archaeobotanical taphonomy will be assessed in the following three chapters.

2.6.2 Settlement pattern of the Western Isles in the first millennia

The construction of a structural sequence throughout the two millennia has been at the forefront of archaeological research in the region for much of the 20th century. Such endeavour by multiple researchers inevitably creates controversy, and Atlantic Scotland is no exception. The debate is now in the position where the major settlement forms have been fitted into a general relative dating framework and much of the discourse revolves around the specific dating of various monument forms and therefore concerns certain issues of contemporaneity, such as broch towers and wheelhouses. The relative chronological and typological position of the sites sampled for this study is highlighted within the narrative. The site label of these sites appears in bold after the site name (also see Conventions and abbreviations in Contents). One of the only substantial multi-period site excavated that covers settlement from the Neolithic to the Norse periods is the Udal (Crawford & Switsur, 1977). However, no detailed description of the site has been published and unpublished material was unavailable, therefore this regional review does not take the site into account.

Before presenting a chronological narrative of the settlement forms, it is important to highlight the advances in classification of certain monuments that have occurred in the past 10 years. Throughout the 1960's to the mid 70's later prehistoric research was focussed on the dating and origin of brochs, with much of the discussion formed by the sometimes controversial ideas of MacKie (1965, 1969, 1971, 1974). The ultimate aim of the research was to isolate a group of 'true brochs' from the confusing myriad of Iron Age circular structures such as the galleried duns, solid and hollow walled brochs, semi-brochs, crannogs and island duns. These 'true brochs' had a very tightly defined set of architectural features that would form the basis for the construction of theories of their invention and spread. This sustained the consensus that brochs were built by dispossessed elites from Southern England as a result of displacement by pre-Roman Belgic settlement or the Roman invasion. The consensus began to be challenged with the excavations in the Northern Isles of massive drystone structures, such as Bu (Hedges, 1987) and the Howe (Ballin-Smith, 1994), that could represent the antecedents of the brochs without needing to refer to external migration for their introduction. Armit (1990b, 1992) therefore introduced the term Atlantic roundhouse to clarify the typological morass of Iron Age circular drystone structures and provide a classificatory scheme that could simplify these various forms and allow the description of field evidence in a way that recognised the limitation of the survey data. Simple Atlantic roundhouses describe thick single-walled substantial roundhouses of the type demonstrated by Bu that usually stood alone. Complex Atlantic roundhouses, which are generally later but not implicitly so within the classificatory scheme, incorporate intra-mural cells and stairs to allow extra height of the roundhouse. The examples in the Northern Isles, such as the Howe or Scatness (Nicholson & Dockrill, 1998), acted as focal points in an enclosed settlement. The complex Atlantic roundhouses include those brochs that had at least one scarcement taken to signify an upper storey that Armit termed 'broch towers'. Certain researchers (cf. MacKie, 1997, 2000; Parker-Pearson & Sharples, 1999) still use the term 'true broch' whilst others have adopted the Atlantic roundhouse terminology (cf. Harding, 1997; Henderson, 2000b; Gilmour, 2000).

Monument classification is not the only area of contention as dating the various monuments has also proved a breeding ground for controversy (cf. Parker Pearson *et al.* 1996, 1999; Gilmour & Cook, 1998; Parker Pearson & Sharples, 1999; Armit, 2000; Gilmour, 2000, forth.). In view of this, the dating framework used within this study is consciously vague with a wide chronological resolution between monument types. The problems of dating in Atlantic Scotland will be discussed in more detail in Chapter 4. The following synthesis of the settlement record of the Western Isles is based on a variant of the general chronological schemes proposed by Parker Pearson & Sharples (1999) and Foster (1990). Hence, the Iron Age is split into an Early (c. 700 cal BC - 100 cal BC), Middle (200 cal BC - cal AD 200), Late I (cal AD 100 - 600) and Late II (cal AD 500 – 900). The Norse period runs from approximately cal AD 900 - 1100, with no differentiation made for an initial Viking colonisation due to the rarity of excavated Norse period sites in the Western Isles. Figure 2.7 presents the general chronological range of drystone settlement development in Atlantic Scotland.

Turning first to the Bronze Age / Early Iron Age, little published material exists for demonstrable settlements during this period. Indeed the few Bronze Age sites excavated are funerary in character, such as the kerb cairn near Calanais (**CC** - see Section 4.8). Ongoing excavations in South Uist at Cladh Hallan (Marshall *et al.*, 1999, 2000, Parker-Pearson *et al.*, 2001) have revealed a sequence of single-skinned roundhouses slightly revetted into the machair (Figure 2.8). A complex sequence of floor levels associated with slightly altered hearth and wall configurations were recovered from each of the houses, as well as a large assemblage of ecofact and artefacts, some of which were in positions that suggested structured deposition. Radiocarbon and archaeomagnetic dates from hearth deposits suggested an occupation in the early to mid first millennium cal BC. These structures are very different from the substantial free-standing simple Atlantic roundhouses of the Early Iron Age in the Northern Isles and the fact that no simple Atlantic roundhouses have been discovered in the Atlantic West may point to their initial development in the North. The excavations at Gob Eirer in Lewis have revealed a part of an ephemeral single-skinned oval structure within a promontory enclosure, dated to the early to mid first millennium cal BC (**GE** - see Section 4.11).

The later centuries of the first millennium cal BC (MIA) see a proliferation in recognisable settlement forms, in terms of both the variety and number of site types. Some of these sites were the subject of coarse excavation by early antiquarians, epitomised by the systematic clearing out of many structures throughout the Vallay Strand in North Uist by Erskine Beveridge in the early 20th century (Beveridge, 1911). However, a number of modern excavations have focussed on complex Atlantic roundhouse settlements including Dun Vulan, South Uist (Parker-Pearson & Sharples, 1999), Dun Bharabhat (**DB-P**; Harding & Dixon, 2000) and Loch na Beirgh (**LB** - Harding & Gilmour, 2000).

As briefly outlined above, complex Atlantic roundhouses incorporate a wide range of monuments that have two concentric drystone walls with the space between them being bridged at intervals by large flat slabs. This creates a sequence of intra-mural galleries and stairs allowing access from ground level to higher storeys and the wall head. The hollow walled construction, coupled with the bonding effect of the slabs, minimised stone weight and maximised the inherent strength of the structure allowing greater wall heights to be achieved. A number of complex Atlantic roundhouses have one and sometimes two scarcements that probably acted as supports for an internal timber superstructure, as envisaged by Alan Braby in his reconstruction of Dun Carloway in Lewis (Figure 2.9). Clearly, both the internal superstructure and the roof would require a large amount of timber for the many complex Atlantic roundhouses throughout the Western Isles and the procurement of this timber in the largely treeless landscape of the late first millennium BC would have been an important component of the inhabitants' economic strategy.

The dating and character of the material culture during the primary roundhouse levels at the three excavated sites is hard to assess as excavations did not demonstrably reach these levels at Dun Vulan and Loch na Beirgh and the primary levels at Dun Bharabhat were severely truncated by later occupation (see Section 4.2 for more discussion). However, two basic schools of thought exist for the construction and use of these complex Atlantic roundhouses, early dating from approximately mid to late first millennium cal BC (Armit, 1996; Harding & Dixon, 2000; Gilmour, 2000, forth.; Henderson, 2000b; Dockrill *et al.*, forth.) and later dating from the late first millennium cal BC into the first half of the first millennium cal AD (MacKie, 1997; Sharples, 1998; Parker-Pearson & Sharples, 1999). The debate will only be resolved with the systematic dating of a number of sites across Atlantic Scotland that contain primary occupation *within* an Atlantic roundhouse; such a dataset is presently unavailable from the excavations to date.

Modern excavations have also been carried out at wheelhouse settlements at Sollas, North Uist (Campbell, 1991), Baleshare and Hornish Point, South Uist (Barber *et al.* 1989; Barber, forth.), Kildonan III, South Uist (Zvelebil, 1990), Bornais, South Uist (Sharples, 2000, 2001) and Cnip in Lewis (**CN-W**; Armit, 1996, forth. a). Wheelhouses have stone piers that radiate into a clear central area with a focal hearth. The structure resembles a wheel in plan (Figure 2.10). The structure itself was usually revetted into machair sand or earlier archaeological material in certain multi-phase sites. The only timber requirement would be in the roof covering the central area, a significant reduction in the amount of timber needed in the Atlantic roundhouses. Again the dating of this monument form is difficult and controversial as the primary levels were either not reached during excavation or were severely truncated by later occupation. Also the few radiocarbon dates from these primary levels at Baleshare, Hornish Point and Cnip are largely erroneous because of the marine reservoir effect on shell and bulk dating of various animal bone species. However, it is generally acknowledged that wheelhouse occupation began in the last centuries cal BC (as suggested by the dating at Cnip; see Section 4.6) and may continue in to the early third century cal AD, from dates from upper floor levels at Sollas.

Issues of contemporaneity are clearly fraught with interpretative difficulty when comparing the possible date ranges for the Atlantic roundhouses and wheelhouses. Again the debate is somewhat polarised with those researchers advocating early dating of the Atlantic roundhouses viewing wheelhouses as separate chronologically (Harding & Dixon, 2000; Gilmour, 2000, forth.) whereas those favouring the later dating of the Atlantic roundhouses see wheelhouses as contemporary (Campbell, 1991; MacKie, 1997, Parker-Pearson & Sharples, 1999; Barber, forth.). The author's personal view is that the present evidence is insufficient to be conclusive but a certain amount of chronological overlap probably occurred between the later phases of primary Atlantic roundhouse occupation and early wheelhouse occupation (cf. Henderson, 2000b; Armit, forth. b).

However, there are a number of characteristic traits of these drystone structures on which there is something approaching consensus. The first trait deals with the extent to which both the Atlantic roundhouses and wheelhouses display monumentality, in direct contrast to the known structures that precede and post date the Mid Iron Age (Armit, 1992, 1996). This monumentality is both direct and visible, in the form of the striking broch towers, or more subtle in the form of the internal monumentality within the central area of a wheelhouse. Armit goes on to suggest that several aspects of the Atlantic roundhouse tradition developed from the desire of the inhabitants to demonstrate their power within the economic and social landscape. Another trait is the recurrent examples of structured deposition with elements of ritual activity within the domestic setting of the Mid Iron Age, seen especially through the foundation pits in wheelhouses, such as Sollas (Campbell, 1991, 2000) and Hornish Point (Barber *et al.*, 1989). These pits contain a variety of 'votive' deposits including dismembered parts of humans and animals associated with certain artefact types, such as beads and pins. Structured deposition is part of the wider phenomenon seen across the British Iron Age of integrating ritual and domestic activity within the home that differs from the separation of home and burial in previous periods (Hingley, 1992). The third feature on which there is consensus is the growing recognition of other structural forms belonging to the Mid Iron Age that are not substantial stone roundhouses. These include structures that immediately replace the larger roundhouses and wheelhouses, such as single skinned roundhouses inserted into the interiors of Atlantic roundhouses (Figure 2.11), for example at Loch na Beirgh (**LB-R**) and Dun Bharabhat (**DB-S**). Also more simple cellular and rectilinear forms are being recognised, like those revetted into the earlier wheelhouse phases at Cnip (**CN-C** & **CN-R**). There are also a number of sites that are divorced from these multi-phase substantial settlements, such as the cellular building in the moorland at Guinnerso (**GUN**) and the possible funerary site at the estuarine islet of An Dunan (**AD-IA**). The position of these structures in the settlement hierarchy with regards to the larger roundhouses and wheelhouses is an important research question.

At some point in the early to mid first millennium AD (LIA-I), the substantial roundhouses and wheelhouses fall out of use suggesting that monumental construction had lost its significance to Atlantic societies. Smaller cellular buildings were constructed, usually in the shells of earlier Mid Iron Age buildings such as Loch na Beirgh (**LB-C**). A prime example of this sort of cellular structure is the recurring configuration of the 'shamrock' that consisted of small often corbelled cells surrounding a central court with a three sided rectangular hearth (Figure 2.12). These structures would have required far less timber for the roofs and furnishings than the Atlantic and later roundhouses of the Mid Iron Age. The mid to late first millennium AD (LIA-II) saw these cellular units give way to more substantial 'figure-of-eight' or ventral buildings (Figure 2.13). Stratigraphically these structures are sometimes the final buildings in multi-phase Iron Age settlements, such as Loch na Beirgh (**LB-LIA**). They also have been found revetted into machair systems, such as the sequence of three ventral buildings at Bostadh (**BO-LIA**). The structural configuration of these ventral buildings is remarkably consistent with the basic pattern consisting of a large cell, with a central hearth and possible aumbries, from which a smaller cell leads. The single-skinned walls, when surviving higher than a few courses, were usually revetted into earlier archaeological material or machair. No evidence for roofing survives, but a recent replica of one of the houses from Bostadh (Neighbour & Crawford, 2001) utilised a single rectilinear roof covering both of the cells. This created two distinct spatial areas, the cellular lower floor and rectilinear loft space that encapsulates the transition in domestic space that occurred at the end of the first millennium AD with the widespread introduction of rectilinear buildings in the Norse period.

Settlements of Norse date in the Western Isles are surprisingly scarce given the proliferation of place name evidence and the reference to large numbers of raiders and settlers in the contemporary literature. This scarcity relates to the rectilinear buildings being disguised by the mass of Medieval and post-Medieval structures of similar shape and it is likely that many of these later structures and modern townships would have been built over the Norse settlements (Armit 1996, 188). The only published site of Norse date is the site at Drimore machair in South Uist (Maclaren, 1974). The excavations revealed a substantial building measuring 14 by 5 m internally with low wall foundations that may have supported a turf superstructure. A pathway led through an entrance in the north-west of the building and the edges of a large central hearth were recovered (Figure 2.14). The waterlogged nature of the floor deposits precluded more detailed excavation. Further Norse buildings with similar low wall construction have been excavated but await publication from the Udal in North Uist (Crawford & Switsur, 1977), Kilphedir (Smith *et al.*, 2001) and Bornais in South Uist (Sharples, 2000, 2001) and Barvas (Cowie, 1986, 1987) and Bostadh in Lewis (**BO-N**; Neighbour, 2001a).

2.6.3 Subsistence and land use

We have seen from the pollen evidence that certain parts of the landscape would have sustained different forms of agriculture, principally arable and pasture land. However, interpreting more detailed aspects of this agricultural system from pollen and related proxies, such as sediment influx into a loch catchment, is notoriously difficult. This level of detail can only be gained from studying the plant macrofossils and bones from archaeological settlements and from detailed archaeological investigations of the field systems themselves. The review of the pollen and macrofossil evidence above has suggested that barley formed the mainstay of the arable economy for much of the first millennia BC and AD, with hints that oats and flax were beginning to be grown in their own right at the end of the first millennium AD.

The evidence for the faunal component of the agricultural economy comes from a number of zooarchaeological assemblages from various sites across the Western Isles. The assemblages are usually only preserved and recovered from alkaline environments so much of the relevant evidence comes from sites within the machair and allied landscape zones. A number of regional reviews of the later prehistoric assemblages have been made for the terrestrial mammals (Finlay, 1984; Armit 1996, 134-5, 148-50,; Gilmour & Cook, 1998; Mulville, 1999; Thoms, forth.) and the marine resources (Ceron-Carrasco, forth.), as well as evidence from site based reports (cf. Young & Richardson, 1960; Finlay, 1991; Hallen, 1994; Cartledge & Grimbly, 1999; Ceron-Carrasco & Parker-Pearson, 1999; Mulville, 1999; Russell, 2000; Ceron-Carrasco *et al.*, forth).

The terrestrial mammal assemblages are dominated by cattle and sheep/goat throughout the first millennia, representing the basic mainstays of the pastoral economy. The economic benefits from these species include primary products such as meat, bone and leather / wool but also include secondary products, such as dairy products. The importance of dairying within the pastoral economy has long been a 'bone of contention', with the cull of juvenile calves claimed to stimulate and maximise milk production of the mothers (Legge, 1981). Supporting evidence is said to come from chemical analysis of pot residues from Sollas (Campbell, 2000) and from Cladh Hallan (Craig *et al.*, 2000) that indicate dairy products within the residues and pot fabric. However, objections and alternative interpretations have been made for both the juvenile kill-off patterns (McCormick, 1992) and the sampling and methodology of the chemical analyses (Tuross *et al.*, 1996) so caution must be exercised when viewing the pastoral economy as one dominated by dairying. Variable proportions of both pig and red deer have also been found across the sites. The relatively high proportions of red deer (between 20 and 30 % NISP) from four of the later prehistoric sites investigated in this study in West Lewis have been compared to the very low proportions from all of the contemporary assemblages from the Uists (Gilmour & Cook, 1998; Ceron-Carrasco *et al.*, forth.; Thoms, forth.). It has been suggested that this reflects a north-south disparity in the availability of resources and raises the intriguing question of the separation of the deer from the arable crop in the study area. A wide range of species of bird bones have also been found on a number of sites, including Dun Vulan (Cartledge & Grimbly, 1999) and Bostadh (Thoms, forth.), which indicates possible seasonal culling of this wild resource.

The evidence for the exploitation of marine resources comes from shells and the bones of marine creatures, including fish and cetaceans. The main types of shells found from both Iron Age and Norse assemblages include the common limpet *(Patella vulgata* L.), the edible periwinkle (*Littorina littorea* L.) and edible mussels (*Mytilus edulis* L.). Other edible molluscs recovered were the common oyster (*Ostrea edulis* L.) and the razor shell (*Sollen marginatus* L.). There are also non-edible species present in the assemblages, such as the flat periwinkle (*Littorina littoralis* L.), *Cingula cingulus* (Montagu), *Rissoa parva* (da Costa) and a tube-dwelling polychaete, *Spinorbis borealis* (Daudin). All of these species may have arrived at the sites as a by-product of seaweed and their presence on site, especially in their burnt form, has been interpreted as evidence of the burning of seaweed (Ceron-Carrasco, forth.).

Comparison of the published reports on fish bones from the Iron Age, suggests that fishing was primarily for small-scale subsistence (Ceron-Carrasco, forth.). The main species exploited was saithe (*Pollachius virens* L.) and cod (*Gadus morhua* L.), that would have been easily caught from rocky locations from the safety of the shore, with many of the other marine species accidentally taken. The onset of the Norse period sees other species, such as herring (*Clupea heringus* L.), recovered in significant quantities. This perhaps reflects a more diverse fishing economy, including deep-water fishing from boats, which has been suggested from a synthesis of Norse assemblages from the Northern Isles (Barrett *et al*., 1999). Numerous cetacean bones have been found from many sites from the first millennia in the Western Isles that indicates that seal and whale strandings were opportunistically gathered, for meat and bone for tools and structural furnishings, such as door pivots.

So what elements of the human / plant interaction can aid in the interpretation the faunal record? Firstly, there may be evidence for the type and extent of fodder used, a particularly important resource for over-wintering of livestock. Also, direct evidence for seaweed procurement may also be seen within the carbonised plant macrofossil assemblage.

The evidence for prehistoric field systems within the Western Isles is surprisingly rare. The most fertile areas being repeatedly used over millennia can explain this scarcity, resulting in the truncation and destruction of the prehistoric evidence by the later Medieval and post-Medieval rigging. Also, the rising sea level, estuarine material, machair sand and peat usually cover the fragments of field systems that do survive. The overburden then needs to be eroded or removed before the site can be discovered, for example through peat cutting or coastal erosion of machair. Another factor is that the excavation strategies employed on settlement sites until very recently concentrated on the structural entities, with little regard to external middens or old ground surfaces. This reflected the predominance of site-based research questions rather than the more landscape-orientated multi-disciplinary projects initiated in the 90s. The dating of these agricultural features is also problematic as the coarse stone alignments or banks usually have little in the way of direct associated archaeological material. Therefore, relatively coarse *termini ante* and *post quem* are usually provided from bulk dates from peat immediately above and below the features. Finally, the only associated archaeological stratigraphy is usually in the form of old ground surfaces (OGS) and palaeosols. These are notoriously difficult to date because of the erosion and mixing that occurs within the soils and the lack of reliable dating material.

Only six sites have been investigated in detail (Figure 2.3). Of these, five were discovered in areas that are now covered in peat during peat cutting. The other site at Rosinish in Benbecula (Shepherd & Tuckwell, 1977) was located in a machair blow out following a sustained period of erosion. An OGS sealed by midden layers containing Beaker pottery was revealed that had evidence of ard marks and spade cultivation enclosed by a fragment of a field boundary in the form of a shallow ditch. Bulk samples from the OGS, ard fills and overlying midden contained naked barley and some emmer wheat that represent the probable cereals grown in the area.

Two sites have been excavated in North Uist at Loch Portain (Mills *et al.*, 1994) and Bharpa Carinish (Crone, 1993). At Loch Portain a linear stone bank, up to 20 m long and 1-2 m wide, was traced by peat probe back from the peat bank from which the feature was initially exposed. The bank stood in isolation with no associated features or ground surfaces, though a couple of charcoal rich peat layers underlay the feature at the section. These layers were radiocarbon dated to the mid 2nd millennium cal BC and a date from the peat immediately underlying the feature suggests it was built within the first half of the first millennium cal BC. Pollen analysis from the peat bank gave no indications of cereal agriculture and suggested that only rough grazing would have been possible in the wet heathland present at the time of construction. The feature was therefore interpreted as a possible land boundary rather than clearance for arable agriculture. A similar interpretation was given for the sub-rectangular enclosure of a similar date attached to the then collapsed Neolithic chambered tomb at Bharpa Carinish. A later field bank and cairn of Mid Iron Age date were also identified. No palaeosols were associated with the structures and again pollen evidence pointed to the area being covered in wet heathland only capable of supporting rough grazing.

Three sites have also been located in Lewis, one at Sheshader on the east coast (Newell, 1988) and two sites, Tob nan Leobag (Cowie, 1979; Bohncke, 1988) and Calanais farm (Flitcroft *et al.*, 2001), near to the Calanais stones on the west coast. A stone enclosure up to 100 by 50 m was discovered during peat cutting at Sheshader and radiocarbon dating from peat immediately under a section of the wall suggested a late second / early first millennium BC date for its construction. Another charcoal rich horizon was identified below the wall that produced a mid second millennium cal BC date. Pollen analysis from the peat bank section pointed to wet heathland for grazing being present throughout the site's history with some evidence of possible cereal cultivation nearby throughout the first millennia BC and AD. The two sites near to the Calanais stones are different in character to the other sites as they have evidence of multiple field walls and clearance cairns as well as associated palaeosols. Both of the field systems lie either side of an arm of a sea loch and so elements of each system may be contemporary and represent a substantial agricultural landscape. The features at Tob nan Leobag were identified in a number of peat banks and were constructed somewhere between 3220±65 bp and 2355±65 bp (no laboratory provenance available). The composite pollen profile from three sections suggested a final clearance of the remnant birch/hazel woodland before the introduction of both pastoral and arable agriculture, presumably within the field system identified. Another charcoal rich peat layer was identified below one of the features, dated to the mid second millennium BC.

The excavations at Calanais farm are the most detailed investigations into a field system yet undertaken within the Western Isles and much of the palaeoenvironmental analysis is still on-going. However, preliminary analysis and dating has presented a complex sequence of changing land-use in the system that survives under approximately 1.8 m of peat across an area of 2-3 hectares. Much of the detailed analysis comes from a trench 17 x 9 m in the centre of the field system (Figure 2.15). Five phases of activity have been identified, starting with a possible rig and furrow system for cereal cultivation from the preliminary pollen analysis (Verrill, 2000). A single-faced field boundary wall was then established, perhaps separating areas of arable and pastoral activity, indicated by the appearance of tall herb pollen types, astiospores and increased phosphate values (Inglis, 1999). Further soil development occurred, creating a palaeosol accumulating against the field boundary. Increased wetness, podzolisation and peat initiation is then inferred by the laying of a cobbled surface to one side of the boundary wall. The features are then covered by peat, with a date for its initiation of 2222±37 bp (OxA-10091) provided by AMS dating of the peat. Further activity within this wet heathland is indicated by a rectilinear arrangement of stones that could be structural or perhaps indicates attempts at clearance.

There are a number of points of interest that are consistent across some of the sites. Firstly, three of the sites (Loch Portain, Sheshader and Tob nan Leobag) include distinct peaty layers that contain significant quantities of charcoal that are dated from the mid to late second millennium cal BC. These have been interpreted as being the direct result of a form of fire-heathland management. Also, the five sites within or under peat all seem to indicate moves to enclosure of wet heathland from the end of the second and early first millennium cal BC that suggests a regional trend towards control of the more marginal land. The attempts to stabilise the ground surface at Calanais farm also shows the pressures of increased marginality that would have confronted the people in certain previously fertile areas throughout the first millennium cal BC. This marginality would have increased as a result of climatic, pedogenic or even anthropogenic factors leading to podzolisation and peat initiation. On the face of it, this marginality may explain the predominant signal of rough grazing from the pollen evidence. However, this is more a function of the site positions within marginal wet heathland during the first millennium BC. Arable agriculture would have occurred in more fertile soils, such as those in the earlier phases at Calanais farm and would potentially have been closer to the main settlements. The appreciation of the wider archaeological landscape led researchers at Tofts Ness, Orkney (Dockrill & Simpson, 1994; Dockrill *et al.*, 1994; Simpson, 1998) and Old Scatness, Shetland (Dockrill *et al.*, 1995; Simpson *et al.*, 1998) to investigate beyond the confines of the immediate Iron Age settlement, through soil auguring and test pitting. Various palaeosols were discovered and detailed palaeoenvironmental techniques, such as soil micromorphology have identified soil amendment strategies and specific types of agricultural techniques, such as plaggen manuring. An infield / outfield system of agriculture has also been suggested for the Iron Age and later settlement at Scatness. This detail in interpretation of the physical evidence relating to arable agriculture will only be possible through the systematic application of soil surveying and sampling techniques in the immediate landscape catchment of major Iron Age sites in the Western Isles.

2.6.4 Artefactual record

One of the striking features of Atlantic Scottish archaeology is the large find assemblages that have been recovered from many of the settlement sites. This is particularly true of the sites dating from the first millennia BC and AD, especially when compared to the much smaller assemblages recovered from indigenous sites of a similar age in lowland Scotland. This can be explained in part by the excellent stratigraphic coherency, with large volumes of occupation horizons and middens existing on most Atlantic sites. Certain soils, such as machair, also provide excellent preservation conditions for classes of artefacts and ecofacts, such as bone and shell, that rarely survive in the acidic soils across most of Scotland. However, it is still evident that the societies in Atlantic Scotland produced much greater quantities of certain classes of artefact, such as pottery, than their lowland contemporaries. Several theories have been proposed to explain this difference (cf. Topping, 1987; Lane, 1990; Armit, 1992; Hingley, 1992; MacKie, 2000) but one of the main reasons may be because of a perceived lack of wood for storage vessels that would not have been a problem for mainland and lowland societies.

Early research on artefacts in the region concentrated on the exotic material, such as Roman pottery and some fine metalwork, using the artefacts to invoke chronological and cultural parallels within the wider Atlantic continuum (cf. MacKie, 1965, 1969). However, Clarke (1971) demonstrated the dangers of such an approach and highlighted potential avenues for research, such as the processing, functionality and actual use of the more utilitarian objects, that went beyond basic typology and exotic parallels. These ideas have only recently begun to be integrated into artefact studies including the processing and procurement for bone artefacts at two wheelhouse sites in North Uist by Hallen (1994), integrating many lines of artefactual and ecofactual evidence to investigate human processes and activities at Scalloway, Shetland (Sharples, 1998) as well as investigating trade and exchange of certain classes of ornamental artefacts, such as spearbutts across Britain (Heald, 2001).

The artefact assemblages from throughout the first millennia are remarkably similar in the range and diversity of different classes of artefact. The artefacts can be separated into three groups, building on the groups proposed by Harding (forth.) and Henderson (2000b). The first group includes the common finds that have little chronological sensitivity (save the pottery) and represent basic utilitarian objects.

Common finds in the Standard Atlantic Scottish Assemblage of the first millennia BC and AD

- hammerstones
- whetstones
- polishing stones
- spindle whorls

- stone weights (loom, thatch and net)
- 'strike-a-lights'
- quernstones (saddle and rotary)
- pottery

The second group includes less common objects that though basically utilitarian, usually relate to more specialist activities, such as metal-working. Also, some of these objects, such as the moulds and steatite, have more chronological sensitivity and could be used for broad dating.

Rare finds in the Standard Atlantic Scottish Assemblage of the first millennia BC and AD

- simple (not composite) bone combs
- crucibles and moulds
- occasional stone lamp
- wooden utilitarian artefacts
- worked bone and whalebone objects (cf. Hallen, 1994)
- steatite objects (Norse)
- rare prosaic metal objects (ploughshares, nails, blades)
- ard stones and pebbles

The final set of objects have a much greater potential for close dating parallels and most imply the existence of wider contact with mainland Britain and the Atlantic continuum. This contact does not necessarily imply direct trading as many of the objects were probably locally produced, rather it highlights awareness of traditions that existed outwith the immediate regional economy.

Ornamental Atlantic Scottish Assemblage of the first millennia BC and AD

- certain classes of Roman material
- composite bone combs
- ring headed pins
- bone dice
- spiral bronze rings
- certain types of pottery e.g. Samian ware
- beads

In the context of this study, it is important to highlight the artefact types that would have been used in the processing of the plants and the innovations that occurred during the first millennia that would have increased the efficiency of this processing. Turning first to arable agriculture, there are a number of different artefacts that would have been used in the harvesting and the processing of the crop. It is generally acknowledged (Greig, 1991; M Jones, 1996) that ards would have been in use with stock throughout the British Isles in the first millennium BC and that mould boards would have been introduced at some point in the first millennium AD. No ards, stone ard shares or plough pebbles have been found in the Western Isles, though stone ard shares have been located from a number of sites across the Northern Isles and Caithness and Sutherland and plough pebbles were found at Jarlshof, Shetland (Hamilton 1956, Plate XX). However, a couple of possible whalebone ard shares were identified from the wheelhouse at Foshigarry, North Uist (Hallen, 1994) and two iron ploughshares were found in secondary contexts at the wheelhouses of Cnip (Armit, 1996, forth. a) and A Cheardach Bheag in South Uist (Fairhurst, 1971). These ploughshares of the first millennium AD would have resulted from the technical innovations of the previous millennium in the working of iron. They created a much stronger ard or plough than would have been used previously, allowing harder soils to be turned and producing less wear on the object. It has been suggested that the discovery of these ploughshares within possible abandonment phases indicates forms of structured deposition and the importance of the agricultural cycle to the belief systems of the inhabitants (Hingley, 1992). These objects would have been used and if broken discarded in the fields away from the immediate settlement and so one of the only ways that they could be found during settlement focussed excavations is in votive deposits. This may explain the absence of other ard and plough parts on excavated sites in the Western Isles as these parts are usually found in Atlantic Scotland as stray finds away from settlement sites or within large area excavations on sites such as Jarlshof.

Further iron objects are known from across Scotland that could have been used for agricultural purposes, including reaping hooks, sickles and scythes, but these are almost exclusively found in Roman contexts or special Romano-British and later hoards (Hunter, 1997). The tools and technology were not generally adopted on indigenous sites until later in the first millennium (Hunter, pers. comm.). It is likely that organic artefacts were used for the various digging and reaping functions and a number of antler picks and whalebone spades have been recovered from Iron Age and later sites in the machair (Hallen, 1994).

The other general class of artefact that survives on most sites that relates to plant processing are the coarse stone tools. These include hammerstones, grinders and pestles that would have been used to grind various plant products, usually within saddle querns or equivalent. One of the more important innovations for plant processing was the adoption of the rotary quern. The exact date of this transition is unknown and consequently a subject of debate (cf. Caulfield, 1977; Armit, 1991; MacKie, 2000a). However, it seems likely that once adopted in one part of an area the superiority of the rotary over the saddle quern would ensure that its adoption would be archaeologically simultaneous across the rest of the area, creating a 'quern replacement horizon' within the archaeological record. This superiority is based on the amount of grain that could be processed as well as the consistency in grinding of the flour. Indeed, MacKie (2000) has argued that some of the top stones of disc querns have wear evidence indicating that they could be adjusted to give coarser and finer grinding.

2.6.5 Social interactions

It is sometimes easy to abstract humans from the archaeological remains that are excavated, concentrating on the objects, whether artefacts or ecofacts, rather than the people who deposited the remains. A concerted effort has been made throughout the 90's in British archaeology (cf. Hingley, 1992; Haselgrove, 2000) to identify approaches and methodologies to overcome this separation between material culture and people. Research on the Middle Iron Age in the Western Isles has produced a wide variety of different ideas that attempt to engage with the way that people lived in their houses and the wider landscape.

The way that people viewed and used the interior of their homes has interested many researchers. There is a tendency to interpret archaeological structures in terms of simple economic necessity, where people get on with the prosaic things in life like eating and sleeping. However, a picture of sophisticated social practices is beginning to emerge in the way that people viewed their living area. A growing corpus of evidence has been recovered for 'structured deposition' playing an integral part in not only the day-to-day life of the inhabitants of a domestic dwelling (Hingley, 1992) but also in the life history of the house itself (LaMotta & Schiffer, 1999). Many votive deposits of cremated animals and humans were recovered from pits below the floors at the wheelhouses at Hornish Point (Barber *et al.*, 1989) and Sollas (Campbell, 1991, 2000). This suggests that the foundation and establishment of the dwelling early in the life history of the wheelhouse was intimately linked to personal expressions by the inhabitants of life, death and the agricultural cycle. Parker-Pearson & Sharples (1999) have argued that the monumental nature and structural configuration of brochs means they can be viewed as 'cosmological encoders'. In other words, the monumental domestic domain incorporates aspects of the ritual and symbolic with binary opposition (e.g. brochs 'above ground'; wheelhouses 'below ground') an implicit metaphor for establishing the social credentials and standing of the inhabitants.

However, these ideas are yet to be tested as no demonstrable occupation surface within a complex Atlantic roundhouse has been excavated under modern conditions within the Western Isles. However, methodologies are being perfected that could be used to approach these questions, through the detailed sampling of floors both on a micro (Milek, 2001) and macro level (Smith *et al.*, 2001). Such a sampling approach was undertaken from an occupation surface from one of the 'figure-of-eight' structures at Bostadh, the results of which are referred to in Section 5.4.

The social landscape has also been seen as an important research area. One of the main research questions stemming from this interest is the way that society was organised, with the various settlement forms and the material culture associated with the structures compared to present various models of social structure. For example, the relationship between the people who lived in complex Atlantic roundhouses, broch towers and wheelhouses has been examined for many years. MacKie (1965, 1969) suggested that 'true brochs' were the fortified homes of southern elites fleeing the Roman invasion, with all the other classes of monument, such as the island duns, housing the indigenous 'lower classes'. Barber (1985) postulated that there was in fact a three-tier system, with the higher echelons within the brochs, the middle classes in the duns and the peasant class living in the wheelhouses. Parker-Pearson & Sharples (1999) suggested that the presence of higher proportions of pig and larger sizes of fish from the midden abutting the broch at Dun Vulan, compared to assemblages from the wheelhouse Kildonan III (Zvelebil, 1990), indicated higher status inhabitants lived in the broch than those in the wheelhouses. However, Armit (1992, 1996) pointed to the high density and even spacing of complex Atlantic roundhouses across the landscape in Barra. From this, he concluded that they formed the standard unit of settlement throughout the region and were inhabited by a variety of social levels, with status displayed in other ways, such as the size of the structures or resource richness. In a recent paper (Armit, forth.b), he also argues that the same unit of land controlled by the inhabitants of an Atlantic roundhouse could have supported a multiple number of wheelhouse settlements, in a repeated form of land inheritance.

Despite the obvious inherent problems of establishing stratigraphic association and structural contemporaneity (see Section 4.2.2), these debates highlight a further avenue for research within this study. Can material culture, in this case archaeobotanical remains, be used to assess the social interactions between the various inhabitants of the sites sampled?

2.7 Research themes of study

This review of past palaeoenvironmental and archaeological research has highlighted a number of avenues of enquiry when investigating the use of plants by human groups in the first millennia. The research themes to be explored can be broken in to three main groups; 1) the approach taken and methodology adopted 2) the taphonomy of the fossil record and 3) the interpretation of the remains.

2.7.1 Methodological research themes

The review highlighted a number of gaps in the basic dataset and present knowledge that could start to be filled through an integrated sampling strategy in West Lewis. Firstly, the chronological and spatial range of the archaeobotanical assemblages analysed prior to this study were discontinuous and variable in coverage. Only a single archaeobotanical assemblage had been analysed from Lewis prior to this study. Also, there were very few assemblages from the Western Isles relating to the important chronological transitions of the Late Bronze Age and Early Iron Age and the Late Iron Age and Norse. Finally, no assemblages had been recovered from funerary monuments of the first millennia BC and AD. In general, the scarcity of archaeobotanical assemblages reflected the gaps in the general archaeological record. Filling this gap was seen as one of the primary aims of a number of the research projects from which the archaeobotanical assemblages of this study were sampled. In this way, a relatively comprehensive range of periods and structural types were sampled (see Chapters 3 and 4).

Another gap in most of the archaeobotanical assemblages was the lack of identification and meaningful inter-site analysis of charcoal recovered, though interesting insights were provided by the charcoal analysis at Allt Chrisal (Boardman, 1995a) and Eilean Domhnuill (Crone, unpubl.).

Therefore, full charcoal analysis was undertaken for each assemblage, including genus identification, roundwood and timber differentiation and ring counts.

However, the main methodological research theme related to the way that sites are sampled. Prior to 1995 most published archaeobotanical assemblages in the Western Isles and Atlantic Scotland in general stemmed from single site excavations. Though most samples were taken from extensive multi-phase settlements allowing useful intra site comparison between different phases, the sampling strategies employed on each of the sites were slightly different, meaning inter site comparison was more difficult. van der Veen (1992) had demonstrated the interpretative value of a statistically valid regional sampling strategy, allowing detailed statistical interpretation of archaeobotanical assemblages from a number of Iron Age and Romano-British sites in North East England. The main methodological research aim was therefore to test and establish a regional sampling strategy allowing meaningful statistical inter-site analysis.

2.7.2 Taphonomy

In this study, the term taphonomy is used in its widest sense, including the investigation of both formation and post-deposition processes that shaped the final death assemblage (Evans & O'Connor, 1999, 57-59). A key part of this transformation for archaeobotanical analysis is the processes of carbonisation and subsequent spread of charred material across the site. It is important to establish how the assemblage of any ecofact or artefact accumulates as this then allows a proper appreciation of the type and degree of sophistication of the research questions posed of the data. It has been assumed, both within Atlantic Scotland (cf. Milles, 1986; Bond, 1994; Dockrill *et al.*, 1994; Dickson, 1994; Holden & Boardman, 1998; Smith, 1999) and Britain as a whole (Hillman, 1981; G Jones, 1984; M Jones, 1985, 1996; van der Veen, 1992), that much of the carbonised plant remains recovered from archaeological sites were most likely carbonised on household fires. However, this assumption is rarely tested and so the taphonomy and carbonisation history of the plant macrofossils will be investigated through the use of mineral magnetism (see Chapter 5).

2.7.3 Interpreting the use of plants by humans

Having established a statistically representative data set and an appreciation of taphonomic biases on the formation of the assemblages we are then in a position to assess the various human uses of plants in the first millennia. Four main interpretative research themes have been formulated on the basis of the review above and the questions that can be posed from archaeobotanical assemblages. Basic research questions will be asked for each of the research themes and the potential for answering these questions assessed in the light of the taphonomic biases.

1) Arable agriculture

The first interpretative research theme involves the investigation of the arable economy of the inhabitants of the sites. The basic research questions include:

- What crops are found on the sites and does this change over space and time?
- Were the crops grown locally and where were the crops grown?
- How were the crops grown, harvested and processed?

2) Wood and timber procurement

The second interpretative research theme to be addressed is the type of wood and timber used and the management and procurement strategies employed to maximise what was clearly an important, but limited resource. The three basic research questions include:

- What types of tree and shrub are found on the sites and how did these get there?
- What types are locally derived and is there any evidence for deliberate management?
- What types are exotic to the island, how were these procured and is there any evidence for trade in timber?

3) Gathering of other plant material

The range of plant products gathered, their possible uses and management form the third interpretative research theme. The palaeoenvironmental reconstruction provided by the pollen evidence points to a mosaic of habitats existing during the first millennia. These include the coastal zone, from cliff-side through to seashore communities, the agricultural zone, with areas of both cereal a cultivation and pasture, and finally the widespread moorland and bog. Issues explored include fuel procurement, fodder production and the definitive evidence for the deliberate gathering of naturally occurring plants, such as seaweed on the coast and berried plants within the moorland.

4) The social dimension of plants

The final interpretative research theme involves using the archaeobotanical assemblages as indicators of the social landscape in terms of social stratification and hierarchy, as well as the less prosaic uses of plants within the belief systems of the populations. Reconstructing aspects of the social landscape are approached through the comparison of various concentrations and proportions of plant material at different sites of similar age to assess any major differences that could be interpreted in the light of site function and status. A shift in interpretative resolution will then be undertaken to address the importance of plants in the belief systems, through the investigation of a number of individual samples and sets of deposits that relate to funerary activity and other forms of structured deposition.

Chapter 3: Methodology

3.1 Introduction

This chapter and sections of Chapter 5 outline the methods used to answer the research questions formulated in Chapter 2. These questions were investigated through the integration of the results from three inter-related areas of research; 1) archaeobotanical analysis of 221 bulk samples (Section 3.3), 2) mineral magnetic analysis of the 605 contexts that comprised the sites' stratigraphy (Section 3.4) and 3) experimentation on the production of ash and carbonised plant macrofossils from various fuel types in an attempt to cast light on the taphonomy of the assemblages (Chapter 5). The samples for the archaeobotanical and mineral magnetic analysis were taken from 9 later prehistoric sites in West Lewis, described in detail in Chapter 4. The selection and sampling of these sites from a regional perspective are described in the following section.

3.2 Site selection, description and sampling

3.2.1 General

One of the main research aims of this study was to establish a regional strategy for the investigation of the anthropogenic use of plants, through the statistically valid inter-site comparison of the formation and composition of a number of archaeobotanical assemblages. The way sites are chosen and sampled governs the basic statistical validity of such an exercise (van der Veen & Fieller, 1982; van der Veen 1984, 1985a, 1992; M Jones, 1991). This involves sampling sites at two levels of resolution; 1) the site in the wider archaeological landscape and 2) the sampling of individual sites.

3.2.2 Sites within the archaeological landscape

The sites were excavated over a period of 13 years by a number of different researchers and so the criteria on which they were chosen for excavation were quite varied. However, the sites were excavated for two main reasons; either as part of a wider landscape research project or as a response to erosive threats to the site.

Six of the sites were excavated under two landscape research projects, both operating under the wider Calanais Archaeological Research Project (Harding, 2000). The first saw excavation of three Iron Age sites on the Bhaltos Peninsula on the west coast of Lewis, between 1985 and 1995 (see Figure 3.1). At the time of excavation the sites were seen to represent the main Iron Age settlement forms common throughout the Western Isles (Harding & Armit 1990): an "island dun" at Dun Bharabhat (Harding & Dixon, 2000), a "broch" at Loch na Beirgh (Harding & Gilmour, 2000) and a wheelhouse and cellular complex at Traigh Cnip (Armit, 1996). Excavation initially characterised the form and date of these structural forms with the eventual aim of comparing their structural, artefactual and ecofactual sequences to create an integrated socio-economic model for the area (cf. Ceron-Carrasco *et al.*, forth.). The Uig Landscape Survey (ULS) was the second major research project from which sites have been used in this study. An initial survey in 1995 of the Uig Peninsula, adjacent to the Bhaltos Peninsula (see Figure 3.1), located over 250 sites of prehistoric to post-Medieval date (Burgess & Church, 1996). From this survey, four sites were chosen for excavation due to their surface remains and landscape positions being different to the usual sites excavated across Atlantic Scotland at that time. For example, Gob Eirer was a promontory site with visible remains within the enclosure, An Dunan was a small islet site within estuarine saltings and Guinnerso was a substantial stone rich mound, with few discernible structural features visible within the rubble. Surveys across the Western Isles (Cowie, 1994; Coles & Burgess, 1994; Brannigan & Foster, 1995, 2000; Burgess *et al.*, 1997a) had demonstrated the frequency of the classes of such remains and the lack of representative excavated sites that would allow more detailed interpretation of their date and function. The other three sites were excavated in response to erosive threats. Calanais kerb cairn was excavated in 1995 in advance of a road expansion programme, whilst Bostadh and Galson were investigated due to severe coastal erosion, in 1996 and 1997-2000 respectively. More detailed descriptions of the sites are presented in Chapter 4.

Clearly, all of these sites were excavated following human choices. Therefore, the site selection process cannot be seen as random and consequently the sites are not statistically representative of the total number of sites in the known archaeological landscape (the sample population). However, this is a common problem in landscape orientated archaeobotanical studies (M Jones, 1991; van der Veen, 1992) and the excavation of a *statistically* representative site was not seen as the primary criteria for site selection in the research and rescue projects.

3.2.3 On site sampling

The author's involvement with the on-site sampling only started from 1995 and so the three sites from the first research project in Bhaltos (Dun Bharabhat, Cnip and Loch na Beirgh) were sampled when the excavator deemed a context worthy of sampling, usually due to perceived ecofactual richness or archaeological importance of the deposit. This strategy is known as *judgement* sampling (M Jones, 1991), and is again not statistically representative of the sample population (the individual archaeobotanical assemblages from the total numbered contexts from the excavation) because of the selectivity introduced by the excavator. However, judgement samples comprise only 9% of the total samples analysed in this study (19 out of a total of 221; see Table 3.1) and as Lennstrom & Hastorf (1992) reasoned, such samples are still useful for inter-site comparison as long as caution is exercised in the statistical interpretation.

All of the sites excavated from 1995 onwards implemented a strategy of either *random* or *total* sampling of well-defined, sealed and undisturbed contexts (van der Veen, 1984, 1985a; M Jones, 1991), with the *random* samples chosen at Loch na Beirgh using random number tables (van der Veen & Feiller, 1982). Two samples were taken; a bulk sample of between 14-28 litres for wet-sieving and a routine sample of approximately 0.25 litres, for basic soil tests including mineral magnetic analysis (see below). The bulk sample volume was chosen following past research in the region and beyond (cf. van der Veen, 1985a, 1992; Dickson, 1994; Bond, 1994), the adequate number of seeds retrieved from the preliminary study (Church, 1996) and overall processing efficiency for the wet-sieving programme. For a full breakdown of the sample totals see Table 3.1.

Detailed sampling methodologies were also employed to answer specific research questions on a number of the sites, usually regarding site formation processes. These included close-interval (2cm) sampling for mineral magnetic measurements from a number of sections through hearths and occupation levels at Galson and Guinnerso and interval sampling on a 0.2 m grid across the final occupation level of House 3 at Bostadh (see Chapter 4 for more detailed descriptions).

3.3 Archaeobotanical analysis

3.3.1 General

Most of the research questions on the human/plant relationship were investigated through the analysis of the carbonised plant macrofossils from the bulk samples. The overall sampling strategy is outlined above, with the general and detailed sampling strategies described for each site in Chapter 4.

3.3.2 Bulk sample processing

All of the samples were wet-sieved using a flotation tank, with settling tanks and filters, set up at Calanais farm. The tank was based on the oil-drum design used at Siraf (Kenward *et al.*, 1980) with a 1mm sieve net and 1.0 and 0.3 mm sieves catching the floating material. A large settling tank drained through a series of filters into a lower settling tank from which the water was pumped back up into the flotation tank. Contamination was therefore minimal, with very little material being introduced into the sieves when the pump was run for 15 minutes with no archaeological sediment added to the flotation tank.

Recovery rates of carbonised remains have been shown to vary for flotation tanks (Kenward *et al.*, 1980; van der Veen, 1983; Badham, 1985). A number of recovery tests were run following the initial construction of the wet-seive station (Church, 1996). This involved the addition of carbonised radish (*Raphanus sativus* L.) seeds into nine 14 litre sets of archaeological material from Loch na Beirgh a day before wet sieving, some of which were soaked in water and others dried for the 24 hour period.

Table 3.2 shows the excellent recovery rates, both in terms of material lost and flot recovery, even for the non-treated samples. Therefore, neither drying nor soaking of the samples was employed prior to wet-sieving all the samples. The floated material (flot) and heavier residue (residue) were air-dried.

The material was split into 3 fractions (>4mm, 2-4 mm, 2-1 mm) and sorted under x6-20 magnification. The 0.3 mm flot was not sorted due to time constraints and the sorting from Dun Vulan, South Uist demonstrated that additional information was not gained from this fraction (Smith 1999, 336). Table 3.3 outlines the material removed from the different fractions of both the flot and residue. Some material, such as charcoal and nutshell, was only sorted from the <4 mm fraction as identification is very difficult below this size for certain ecofact classes. Uncarbonised plant macrofossils were sorted but did not form part of the analysis, as waterlogged conditions were only discovered at the base of the excavations at Loch na Beirgh (Harding & Gilmour, 2000).

When all the flots were sorted, a further recovery test to gauge the flot efficiency was devised involving the comparison between the number of cereal caryopses sorted from the flots and a number of randomly chosen residues (see Appendix A for detailed discussion). A recovery percentage for each sample was calculated for the proportion of the total caryopses within the flot. Only samples with greater that 10 cereal caryopses were chosen for this exercise, as lower numbers would create unrepresentative percentages. The percentage of caryopses in the flot was then averaged for each site. Table 3.4 shows the recovery rates from six of the sites chosen for this recovery test. Five of the six sites had flot recovery rates over 80% with three of the sites over 90%. Neither soil moisture content nor organic content of the soil matrix seemed to make any difference to the flot recovery. Therefore, the general sorting strategy was to sort the flot fractions in their entirety and the residue fractions from the sites in the machair (Cnip, Bostadh, Galson) and Loch na Beirgh that had good bone and shell preservation present in the residues. The <4mm fraction of all the residues was also sorted for charcoal. An exception to this rule was Gob Eirer, where total sorting of all the fractions was required. The flot recovery was very low (8%) due to the complex post-depositional soil processes on the site. Widespread podsolization and leaching meant that much of the carbonised material had filtered and crystallised the mobile ferrous oxides, making the macrofossils much more dense than normal. This meant that the macrofossils were unlikely to float off and remained in the residues. The recrystallisation process also meant that many of the more fragile carbonised components, such as the seeds and chaff, were mechanically split and destroyed, resulting in a very poorly preserved archaeobotanical assemblage dominated by the more robust cereal caryopses.

3.3.3 Identification and data recording

All macrofossil identifications were checked against botanical literature (Long, 1929; Beijerinck, 1947; Berggren, 1969, 1981; Schweingruber, 1990; Dobson, 1992; Anderburg, 1994) and modern reference material from collections in the Department of Archaeology, University of Edinburgh. Both the seed and the charcoal reference collections were substantially increased through material collected from Lewis and other sources by the author. The general term 'seed' is used in the text throughout, without consideration for the correct botanical terminology. Table 3.5 lists the full botanical name, common name and plant part for all the identifications made in this study. Nomenclature follows Stace (1991), with ecological information taken from Grime *et al.* (1988), Clapham *et al.* (1989), Stace (1991), Pankhurst & Mullin (1994), Flora Europaea (Royal Botanic Garden Edinburgh, 1998). Also, entries in the Journal of Ecology on the 'Biological flora of the British Isles' were consulted for detailed information on individual species (cf. New, 1961; Sobey, 1981).

Charcoal identifications were made on carbonised fragments of >4 mm diameter. The total fragments and weight from both the flot and residue from each sample was calculated. Up to 20 fragments were then randomly chosen for identification from the flot, using a riffle box, random number tables and a 2D grid. Statistical representation was still maintained for most of the samples and all of the site blocks, following the test outlined by van der Veen & Feiller (1982). The arbitrary cut-off point of 20 identifications was chosen, as it would allow easy conversion to percentages as well as saving time. The fragments were generally identified to genus, with the number of fragments and weight for each genus recorded. The fragments were also categorised into roundwood or timber and the number of rings noted. Many of the roundwood fragments allowed ring counts from the central pith to the outer ring and bark, allowing the age of the fragment to be estimated. However, estimations of seasonality were not possible as the rings were usually too small or warped by the carbonisation. Other miscellaneous observations, such as bore holes or vitrification, were noted when appropriate.

It became apparent during the initial charcoal identification from Loch na Beirgh that Ling Heather (*Calluna vulgaris* L. Vill.) was an important component of the assemblage. It also was clear that different age profiles were emerging from the fragment ring counts of the various blocks of analysis. These may relate to specific procurement patterns or heathland management. It was therefore decided to identify and ring count as many Ling heather fragments as possible within all the samples that contained more than 20 fragments in the flot. This was a relatively quick procedure as the dimpled surface of Ling is easily recognised and the rings are generally easy to count.

Table 3.6 summarises the identification and counting criteria for the cereal grain and chaff, based on van der Veen (1992). The preservation was also recorded for each cereal grain identified, following the index devised by Hubbard & al Azm (1990). Again, the identification criteria for the wild seeds were based on those outlined by van der Veen (1992), with the grasses (Poaceae undiff.) and sedges (*Carex* spp.) only differentiated by large/medium/small and biconvex/trigonous respectively. Each seed was given a count of one even if broken, except large fragments that were clearly from the same seed. Other miscellaneous plant parts, such as hazelnut, seaweed and heather leaf fragments, were given a fragment count rather than a quantifiable count due to multiple fragmentation (cf. Dickson, 1994).

It became clear during the sorting of the samples that a wide variety of culm parts and rhizomes were present in many of the assemblages. Almost all of these were presumably of the grass family (Poaceae undiff.) though some other monocotyledenous plants would have been present. Though Hather (1993) has highlighted the importance of these elements, they were only identified to generic element type (e.g. culm node, culm base, rhizome) as detailed SEM research would have been too time consuming for this study and of little extra interpretative value. Most researchers in Northern Britain (cf. van der Veen, 1992; Dickson, 1994; Boardman, 1995a; Bond, 1994; Holden, 1998a; Smith, 1999) have followed this level of identification. However, in this study all three generic element types were split into greater than and less than 2mm. This stemmed from the observation that cereal culm nodes and bases are generally greater than 2mm in diameter and rhizomes, culm nodes and culm bases from other grasses and turf were less than 2mm. Therefore, the general proportion of material from cereal straw could be separated from other grassy material, especially that introduced with the fuel source (see Section 5.7 for further discussion).

3.3.4 Standardisation of the data

Two general groups of data form the statistical basis of this study following G Jones (1991); the sample and the site block. The sample data is made up of two datasets from the charcoal and carbonised plant macrofossil identifications from the individual bulk samples, whilst the site block data is the amalgamation of all the samples from the site phasing blocks outlined in Chapter 4, again resulting in a charcoal and macrofossil dataset for each block. The justification for this amalgamation is based on the taphonomic arguments outlined in Chapter 5.

A number of samples were omitted from the analysis, before standardising the site datasets. Some samples were eliminated from all analysis because of stratigraphic considerations. The artefact and ecofact assemblages from certain generic context types can become mixed from different periods due to the complex interplay of site formation processes operating in Atlantic Scotland. Table 3.7 outlines all the generic context types from which the samples were taken in this study and highlights the context types that have been omitted and the justification for the action. Every sample was assigned to a generic context types from site observation by the author and reference to the site record. Clearly, this involved the simplification of the extremely complex phenomenon of site formation process. For example, the formation processes of 'floor levels' have generated much research and discussion in Atlantic Scotland (cf. Matthews, 1993; Carter, 1999; Schwenninger, 1999; Smith *et al.*, 2001; Milek, 2001). However, this classification allowed samples of specific generic context types with similar archaeobotanical taphonomy to be chosen for analysis. It also highlighted samples from context types that may have been formed from material from different periods that were then removed from all of the statistical analysis. For example, mixed material comprising wall fills was not included in the analysis as it was likely to represent redeposited material from an earlier phase. This rejection of certain context types introduced an element of human judgement into the site assemblages; however it means that the archaeobotanical material analysed had similar taphonomic histories and the procedure also largely removed the problem of inter period mixing of the archaeobotanical material.

Standardisation of the data is needed to compare samples, as the total of the quantifiable components in a sample relate to both sample size and macrofossil density. The first method of standardisation removed the problem of variable sample size through converting certain elements into element per litre. This data was used in sample and inter-block comparison with macrofossil concentration as an important component of the analysis, such as total quantifiable components and cereal caryopses per litre. These analyses included all the samples except for those omitted due to their generic context type. The second method of standardisation was the conversion of the data to percentages of each category of data within the sample and block (cf. van der Veen, 1992). Samples with low frequencies of remains and species were removed prior to this method of standardisation. An arbitrary cut-off point of 10 identifiable components was chosen to allow ready conversion to percentages for the samples. The categories of data comprised grain, chaff, wild species and charcoal. Table 3.5 presents the data category of all the species and elements recovered from the study. In summary, all the statistical analyses of the archaeobotanical data within this study are based on the data standardised by 1) elements per litreage or 2) percentages of the data categories. The analyses themselves are described in the text when appropriate.

3.4 Mineral magnetic analysis

3.4.1 Mineral magnetism in soils

Mineral magnetism is the study of magnetic particles that are present in organic and inorganic materials. Research into this phenomenon has been conducted for almost forty years and has concentrated on explaining the composition of the magnetic signals from a variety of sediments, the associated fixing and enhancing mechanisms and also the various applications across the environmental sciences. Much of the background described below has been summarised from Thompson & Oldfield (1986), Clark (1990), Dearing (1994), Maher & Thompson (1999) and Walden *et al.* (1999).

The magnetic signal from a given sediment can be explained in terms of the concentration and type of mineral particles (the mineralogy) and their size and shape (domain state). The main magnetic minerals found in soils are iron oxides, oxyhydroxides and hydroxides. Their magnetic behaviour can be separated into five classes; ferromagnetism, ferrimagnetism, canted antiferromagnetism, paramagnetism and diamagnetism. Ferromagnetic minerals are highly magnetic substances like pure iron and are very rarely found in 'natural' soil horizons. Ferrimagnetic minerals include magnetite (Fe_3O_4) and other highly magnetic materials, accounting for much of the magnetic enhancement in soils (Tite & Mullins, 1971; Mullins, 1977). Canted antiferromagnetic minerals include iron minerals with weaker magnetic signals, such as haematite (αFe_2O_3). Paramagnetic minerals also contain a weak signal, stemming from the small proportion of iron in their compounds. Diamagnetic minerals include a range of materials that have a very weak or even negative magnetism and includes minerals with no iron content, such as quartz and calcium carbonate, and also organic matter and water. The size and shape of these minerals, the domain state, is also important as different grain sizes exhibit different magnetic characteristics. Magnetic energies are created from regions within the grains, called domains, which are magnetised uniformly in one direction. Very small grains do not contain domains, so exhibit superparamagnetic (SPM) characteristics where thermal energies create signals similar to magnetic energies. As the size of the grain increases, the magnetic energies dominate over the thermal energies with the appearance of domains. Grains that contain only one domain, referred to as single-domain grains (SD), are slightly larger than SPM grains. Pseudo-single-domain grains (PSD) and multi-domain grains (MD) indicate increasingly larger particles that contain competing domains, resulting in an overall lower total energy.

The enhanced magnetism of soil compared to subsoil was first observed by Le Borgne (1955, 1960), who highlighted two main enhancement mechanisms, heating and bacterial action, within continental soils. Further fixing and enhancing mechanisms include general pedogenic processes, such as weathering, the input of post-industrial fallout from the burning of fossil fuels ('fly ash'; cf. Maher & Thompson, 1999) and anthropogenic inputs into archaeological contexts, such as ferromagnetic slag spheres from metal working processes on archaeological sites (cf. Englike, 1991; Sim, 1998). Post-depositional processes can also alter the magnetic properties of the soil, including waterlogging leading to dissolution of the mineral grains and removal by leaching, iron-reducing bacteria and also general pedogenesis, especially slope processes (for a good example in Atlantic Scotland, see Maher, 1981).

Analysis of the various magnetic signatures of sediments, coupled with the fixing and enhancing mechanisms, has a wide variety of applications in the environmental sciences. These include 1) geological prospecting (cf. O'Reilly, 1976), 2) soil identification, characterisation and pedogenesis (cf. Mullins, 1977) 3) modern and past environmental reconstruction (cf. King & Channell, 1991), 4) hydrology and sedimentology (cf. Oldfield *et al.*, 1981) 5) climate studies (cf. Maher & Thompson, 1999), 6) pollution studies (cf. Williams, 1991) and finally 7) archaeology.

3.4.2 Mineral magnetism in archaeology

There are many applications of mineral magnetic research in archaeology, on the scale of both the site and the wider landscape (Oldfield *et al.*, 1985; Dalan & Banerjee, 1998). The research into the wider landscape usually involves the interpretation of mineral magnetic profiles through geomorphic and sedimentary catchment sinks, such as lake and river terrace profiles (cf. Dearing, 1992). Many of these studies involve the integration of other proxy records, such as pollen analysis, to create a complementary palaeoenvironmental reconstruction. The use of mineral magnetism in this study is more concerned with site based applications.

Heating as the primary mechanism for mineral magnetic enhancement on archaeological sites was first recognised by Le Borgne (1955, 1960), with the main processes of enhancement demonstrated by Tite & Mullins (1971) and Mullins (1977). This enhanced signature from burning allowed archaeological sites to be investigated in a number of ways. The most obvious application was the use of mineral magnetism in archaeological prospection, as first highlighted by Aitken *et al.* (1958). The basic principle is the use of magnetometry in distinguishing the presence, form and extent of archaeological sites through the comparison of the magnetically enhanced archaeological material and the surrounding soils (Clark, 1990). This process can be completely non-invasive or involve interval sediment sampling for magnetic susceptibility and phosphate processing (Batt *et al.*, 1995).

Mineral magnetism also forms the theoretical basis behind archaeomagnetic dating (Clark *et al.*, 1988), with the *in situ* hearths of Atlantic Scotland ideal for this form of dating (cf. Batt & Dockrill, 1998). Evidence of *in situ* burning on archaeological sites forms the focus for much of the mineral magnetic profile across a site (cf. Linford, 2000; Linford & Canti, 2001) and a number of researchers have used this hypothesis to identify the likely position of a hearth (cf. Bellomo, 1993; Morinaga *et al.*, 1999) or structural conflagration (Krawiecki, 1982). The identification and spread of burnt material and ash through mineral magnetism, with general reference to site formation processes, has been demonstrated on sites comprising largely negative features (cf. McClean & Kean, 1993) and more complex urban stratigraphy (cf. Boucher, 1996). The first steps to distinguish and separate the mineral particles from anthropogenic and natural enhancement processes have also been attempted for ash rich deposits on archaeological sites (cf. Crowther & Barker, 1995; Marmet *et al.*, 1999; Peters & Thompson, 1999). This lead to the recognition that different fuel types could produce slightly different mineral magnetic signatures, a theme explored in more detail in Chapter 5.

3.4.3 The application of mineral magnetism in this study

Mineral magnetism has recently been used in Atlantic Scotland at Scatness, Shetland (Dockrill *et al.*, 1995; Batt & Dockrill, 1998) and St. Boniface, Orkney (Peters & Thompson, 1999). Both exercises involved the integration of mineral magnetism with other chemical and environmental evidence, to determine source material and formation processes through sections of archaeological material in a soil test pit and eroding section adjacent to major Iron Age and Norse excavations (Nicholson & Dockrill, 1998; Lowe, 1999). The enhancement observed in archaeological layers at both sites were demonstrated to stem from the input of ashy material into the various context types, with a magnetic enhancement factor of over 200 at St. Boniface. Unmixing of 85 hysteresis loops from St. Boniface showed that superparamagnetic grains were the predominant magnetic component, derived from the ash. On both sites, this ash was either dumped as part of midden material from the sites or deliberately incorporated into soil horizons, a deliberate amendment strategy also demonstrated through mineral magnetism at Tofts Ness, Orkney (Dockrill & Simpson, 1994). Magnetic susceptibility, in conjunction with other archaeological and environmental techniques, was also used at Dun Vulan, South Uist (Parker Pearson *et al.*, 1996; Marshall & Smith, 1999; Giles *et al.*, 1999) and Kilphedir, South Uist (Smith *et al.*, 2001) to investigate site formation processes, with specific reference to house activity areas. Grid samples were also taken from a kerbed cairn in Barra that identified specific areas of in situ burning within the body of the structure (Merrony & Frusher, 2000). Preliminary mineral magnetic analysis by the author of on-site archaeological sediment from Loch na Beirgh showed marked magnetic enhancement of certain generic context types such as hearth material, ash spreads and middens (Church, 1996). It was also noted that the samples with marked magnetic enhancement contained high concentrations of carbonised plant macrofossils, establishing the link between the spread of ash and plant material across the site.

Mineral magnetism was therefore seen as an invaluable tool for disentangling the complex taphonomy and formation processes of the archaeobotanical assemblages in this study (see Chapter 5). A preliminary level of analysis was designed, involving the measurement of the magnetic susceptibility of all the samples. This information would be used to answer a number of basic research questions including;

1) Was the magnetic enhancement observed at Loch na Beirgh repeated at the other sites?
2) Was this magnetic enhancement largely the product of the spread of ash from hearths?
3) Was the link between magnetic enhancement, ash content and carbonised plant macrofossil concentration repeated across the sites?

More detailed mineral magnetic analysis was also employed in order to source the fuel types used on the various sites. The research background, methodology and results of this research are outlined in Chapter 5.

3.4.4 Sampling, sample measurement and quantification

The sampling for the preliminary magnetic susceptibility reflected the general strategy employed across the sites for the bulk samples (see Section 3.2). More detailed sampling was also employed at specific sites to answer the research questions outlined in the section above. This sampling is described in the appropriate sections of the site descriptions in Chapter 4.

Magnetic susceptibility measures the 'magnetizability' of a material (Dearing, 1994), through placing the sample in a small alternating magnetic field and measuring the response. Samples were prepared for lab measurement by first describing their texture and colour using a Munsell colour chart (1992), before drying the sample for 24 hours at 40°C, to remove the diamagnetic component of the water, and then sieving the dried soil through a 2mm gauge, to remove large archaeological and natural clasts. Volumetric magnetic susceptibility (κ_{lf} and κ_{hf}) was then measured at high and low frequencies using a Bartington MS2 susceptibility bridge, and the soil weighed. This allowed the two basic measurements of mass specific magnetic susceptibility (χ with units of $\mu m^3 kg^{-1}$) and frequency dependent susceptibility (κ_{fd} as a percentage) to be calculated, following Dearing (1994). Inter sample comparison of χ removes the variability in sediment compaction and the effect this may have on the magnetic value of the material and κ_{fd} allows an estimation of the concentration of superparamagnetic grains (see Table 3.8).

3.5 Summary of methodology

The overall methodology employed to retrieve, process, identify and standardise the data prior to quantification and analysis can be summarised in a series of stages.

Sampling

1. Sampling of site in landscape; research project or threat driven.
2. On site sampling prior to 1995 with no involvement of author = judgement sampling.
3. On site sampling from 1995 onwards with personal involvement or consultation of author = random or total sampling.
4. Bulk sample of 14-28 litres and routine sample of 0.25 litres taken from every context sampled.

Bulk sample processing

5. Wet sieving using Siraf type tank at Calanais farm.
6. Air drying of flot and residue.
7. Sorting of all flot fractions and <4mm. fraction of residues, with limited sorting of smaller residue fractions depending on recovery rates of archaeobotanical material in flots or presence of other ecofacts, such as fish bone and shell.

Archaeobotanical identification

8. Charcoal fragments <4 mm. counted and weighed for all flots and residues.
9. Up to 20 charcoal fragments from all flots identified to genus, growth rings counted and each genus total weighed.
10. All Ling Heather (*Calluna vulgaris* L. Vill.) from flots identified, growth rings counted and genus total weighed.
11. Cereal grains, chaff and wild plants identified and counted for all sorted fractions.

Data standardisation

12. Removal of samples with generic context types with possible inter period mixing.
13. Assign period blocks for individual samples; analysis to be based on the level of the sample and block.
14. Standardisation procedure 1 = Quantifiable components (QC), caryopses, charcoal fragments and charcoal weight per litre were calculated for each individual sample and block.

15. Removal of samples with less than 10 QC's (charcoal not included in this stage).

16. Standardisation procedure 2 = conversion of period block data into percentages for both charcoal and other plant macrofossils.

Routine sample processing for mineral magnetism

17. Basic soil description (texture, Munsell colour).

18. Dry soil at 40°C for 24 hours to remove diamagnetic component of moisture

19. Sieve soil through 2mm gauge to remove larger clasts.

20. Measure volumetric low and high frequency magnetic susceptibility (κ_{lf} and κ_{hf}) using a Bartington MS2 susceptibility bridge.

21. Weigh soil.

22. Calculate mass specific magnetic susceptibility (χ) and frequency dependent susceptibility (κ_{fd}).

The data was then ready for quantification and analysis, with only the period blocks from Cnip, Dun Bharabhat and the Late Iron Age blocks from Loch na Beirgh not statistically representative of the contexts excavated on the nine sites. All the other blocks were statistically representative meaning most of the standardised data could be directly compared on an inter and intra site basis.

Chapter 4: Description and dating of the sites

4.1 Introduction

This chapter introduces the sites sampled throughout the study area. They are described in the order of excavation as this allows a greater appreciation of the evolution of the research questions governing their excavation, as well as the development of the sampling and dating strategies. The section for each site describes the background to the excavations, the major phases revealed, the dating of the phases and the sampling strategy employed on the site.

4.2 Dating the sites

4.2.1 Site blocks

Many of the sites are multi-phase, with the phases usually based on sets of deposits associated with certain structural forms. These phases are used as the basis for designing the dating strategies of the sites, following Armit's advocacy of the primacy of absolute and artefactual dating over comparative structural dating in Atlantic Scotland (1991). Clarke (2001) recently argued that this dependency on structural form as the basis for site phasing overlooked more subtle and potentially more important chronological changes that occur within the artefactual and ecofactual assemblages. He argued that it is these changes, rather than changes in structural form, which are the more important chronological and cultural markers for human life. Though this is an important point to be addressed by future research, the post-excavation analysis of the artefact and ecofact assemblages for most sites in this study is still on-going, meaning such an approach would not be possible at this stage.

As outlined in Section 3.3.4, aspects of the analysis of this study are based on site blocks. These blocks represent the main periods on the sites, sometimes amalgamating a few of the phases proposed by the excavators. For example at Loch na Beirgh, the Cellular Block (**LB-C**) represents Phases 5 to 9 in the published account of the structures and stratigraphy (Harding & Gilmour, 2000). All of these phases represent re-organisation of the basic structural theme of small conjoining cellular features within the shell of the complex Atlantic roundhouse, over a period of approximately 4 centuries (2nd to 6th centuries cal AD). The amalgamation was undertaken to create a manageable number of blocks for analysis with enough samples to present a generalised picture of plant exploitation from that period. Also, many of the phases were relatively short-lived and could not be separated chronologically by radiocarbon dating. A new block was always created when major structural change could be detected e.g. the change from a single roundhouse (**LB-R**) to several cellular buildings (**LB-**

C) at Loch na Beirgh. The justification for block amalgamation is given in the site descriptions where appropriate.

4.2.2 Dating in Atlantic Scotland

On face value, Atlantic Scotland should be a good region for dating these blocks, because of the excellent stratigraphic preservation associated with clearly identifiable structural forms. However, this is not necessarily the case for a number of reasons. Firstly, establishing stratigraphic association is not as straightforward as first seems. Many sites of Iron Age date have large amounts of substantial masonry creating barriers between sets of contexts that abut the walling on both sides. This sometimes creates uncertainty about the association with structural components and sediment contexts. For example, the excavators of the Iron Age complex at Dun Vulan, South Uist have associated a large external midden with a broch (complex Atlantic roundhouse), despite no direct stratigraphic association between the interior of the roundhouse and the midden (Parker Pearson *et al.* 1996, 1999; Parker Pearson & Sharples, 1999). No material associated with the interior occupation of the roundhouse in its primary form was excavated. The midden accumulated from the 1st to 3rd centuries cal AD, which lead the excavators to equate the material from the midden to refuse from the inhabitants of the roundhouse, a conclusion reached through the excavators inclination for the late dating of brochs (Sharples & Parker Pearson, 1997; Sharples, 1998). Comparisons were then made between the economy and material culture from the Dun Vulan midden (= broch) and material from wheelhouses in the Uists, leading to hierarchical distinctions being made between the inhabitants of the broch (higher status) and the wheelhouses (lower status). A number of objections have been made to this comparison (Gilmour & Cook, 1998; Armit, 2000), based largely on the arguable association with the broch in its primary form and the midden. Another important aspect to this debate is the problem that secondary occupation poses for linking stratigraphic phases and creating meaningful chronologies. Many of the Atlantic Roundhouse sites have multiple secondary occupation that can confuse and truncate earlier deposits. For example, at Dun Vulan the top deposits in the interior of the Atlantic roundhouse were excavated to reveal a Late Iron Age 'figure-of-eight' structure, similar in form to the latest secondary structure at Loch na Beirgh. Therefore, Gilmour & Cook (1998) and Armit (2000) have argued that the midden could relate to one of these secondary buildings yet to be excavated within the interior of the Atlantic roundhouse. Indeed, the only way to link the midden with the broch is absolute dating of the primary occupation of the roundhouse, a difficult task given the massive truncation and clearing out of those complex Atlantic roundhouses excavated to 'primary levels' (Gilmour, 2000, forth.). This short case study highlights the difficulties of context association and the need for rigorous dating techniques to resolve the chronological issues. This leads us onto the second major problem in dating in Atlantic Scotland, the reliability of absolute dating.

Armit (1991) outlined the hierarchy of dating media in Atlantic Scotland, rightly placing absolute dating as the best means to date an archaeological phase. He was writing at a time when researchers in the region were attempting to throw off the straitjacket of structural typology that was hindering more flexible interpretation of later prehistory. However, the past 10 years has seen a much more interrogative approach to absolute dating, with many problems highlighted for the region. The first major problem is the reservoir effect (outlined in detail by Aitken, 1990). All of Atlantic Scotland is intimately associated with the sea, and much of the biomass exploited by humans is connected to marine ecosystems in some way, resulting in many of the dating media incorporating marine carbon into their bodies when alive. This includes marine life, such as fish, molluscs and seaweed, but can also include less obvious terrestrial animals that feed off this marine life, including nearly all the birds that have a diet of fish and all of the larger mammals feeding on seaweed. Trial trenching and coring of a number of settlement mounds in the machair of the Uists by AOC in the early 80's (Barber, forth.) revealed many sites of Bronze Age to Norse date from the artefacts recovered. Bulk dates of marine molluscs and large mammal bone were processed, in order to get enough carbon for conventional radiocarbon dating. The resulting dates were very varied, with sites of known structural form, such as the wheelhouses at Hornish Point, producing dates ranging over 1000 years. Clearly, the marine reservoir effect was to blame for much of the variation. Barrett *et al.* (2000) argue a correction can be made for shell and fish bone. However, it is debatable whether the conveyor belt of old carbon in the deep-sea water was constant, the assumption underpinning such a correction. The variation could also have been introduced through the use of more than one entity for the bulk date. Ashmore (1999) highlights the problem of bulk dating through the case study of a metal-working structure at Eilean Olabhat in North Uist (Armit, 1996; Armit *et al.*, forth.). Dating of charcoal from seven bulk samples firmly associated with the metal-working phase produced dates ranging from 1400±90 to 2820±70 bp (laboratory provenance unavailable), an unlikely date range considering the metal-working expertise demonstrated by the smiths. The explanation offered for this variability was the mixing of older wood from the adjacent Neolithic settlement of Eilean Domhnuill (Armit, 1996). Subsequent dating of food residues from pottery suggest a 6th century cal AD date for the metalworking.

Further problems exist using charcoal as a dating medium, even if single entity dating is employed. For example, this study and other extensive analyses of charcoal from later prehistoric and Norse sites in the region (Dickson, 1992; Crone, 1993; Dickson, 1994; Malmros, 1994; Crone, 1998, 1999; Taylor, 1999) have shown that much of the charcoal assemblages recovered are dominated by fragments of coniferous driftwood timber or small fragments of locally-derived deciduous roundwood. Both sets of charcoal have inherent problems for radiocarbon dating, relating to the date of death. For example, the deciduous roundwood, though short-living, can be preserved for thousands of years within peat and then carbonised when the peat is used as fuel (see Section 5.7). The date of death for the coniferous timber is also difficult to estimate as the fragments are usually very small and it is hard to establish how old the tree was or the position of the fragment in the tree ring-profile. Also, much of this coniferous timber is likely to be driftwood, especially the exotic species such as larch (*Larix* sp.), spruce (*Picea* sp.) and fir (*Abies* sp.), that could have been locked in the Atlantic and even the Arctic oceans for unknown periods of time.

The final problem for radiocarbon dates are the radiocarbon plateaux (Aitken, 1990). Figure 4.1 shows the calibration curve for the first millennia BC and AD, following Bronk-Ramsey (2000). The major plateaux occur between 200-350 and 400-800 cal BC, meaning any radiocarbon determination of approximately 2200 C^{14}BP or 2400-2500 C^{14}BP will calibrate within this 600 year period. Clearly, this is an important time period in the development of Iron Age settlement in Atlantic Scotland, especially when considering the development of Atlantic roundhouses and the contemporaneity of sites classes. For example, Gilmour (forth.) plotted all the known radiocarbon dates for Iron Age sites in Atlantic Scotland and argued that 300-400 cal BC marked an important point in the development of settlement in the region as many of the early dates from the site sequences calibrated to this time. However, this is more likely to relate to the statistics of calibration within these radiocarbon plateaux rather than marking any significant point in the structural or cultural development of the region.

4.2.3 Establishing a dating strategy

The appreciation of these problems has led to more rigorous dating strategies being employed by the various research projects in the region, based on the experience gained on the strengths and weaknesses of radiocarbon dating. The direct involvement of the author in the management of the post-excavation of the sites excavated from 1995 onwards has meant that a comparable absolute dating strategy has been formulated for all of the sites within the study. The strategy is based on the absolute dating of cereal caryopses recovered from the bulk samples where possible, with the generous support and encouragement of Patrick Ashmore of Historic Scotland. Historic Scotland's recent policy of single entity dating by AMS (Ashmore, 1999) means single cereal caryopses weighing greater than 0.007 g. can now be dated, removing the bulk dating problem of traditional radiocarbon dating. Cereal caryopses represent the best medium for radiocarbon dating in the region as they are very short-lived (one season's growth), are unlikely to take up old marine carbon and avoid the problems of establishing date of death for charcoal fragments. Clearly, this also has a research advantage for this study as the absolute dates are directly dating the archaeobotanical assemblages from each of the sites.

Researchers at the multi-period excavations at Old Scatness, Shetland have developed a complementary approach by using a variety of absolute dating techniques (Dockrill & Nicholson, 1998; Batt & Dockrill, 1998). Radiocarbon dating of cereal caryopses provides the backbone of the programme, complemented by OSL dating of appropriate sediments and archaeomagnetic dating of *in situ* ash in hearths. The main advantage of the OSL and archaeomagnetic dating techniques is their ability to fill in the gaps left by the radiocarbon plateaux, especially in the first millennium bc. The complementary approach also allows the use of Bayesian statistics (Buck *et al.*, 1996) to narrow down the probable dates of occupation and complementary techniques have also been utilised at Bostadh (archaeomagnetic dating) and Galson (OSL dating). The results from these dating techniques are still awaited and therefore cannot be incorporated into this study.

4.2.4 Chronological resolution

In summary, the dating problems in Atlantic Scotland have meant the establishment of detailed chronologies for the later prehistoric period is not possible. Vigorous discussion is still ongoing over the date of construction and occupation of most site types, with little consensus over basic chronological questions such as the contemporaneity of complex Atlantic roundhouses and wheelhouses. Therefore, the chronological comparison in this study is relatively general, with issues of continuity and change in the use of plants discussed in terms of centuries rather than 'radiocarbon decades' as preferred by researchers such as Ashmore (1996). This seems to be more appropriate when considering the possible occupation span of complex Atlantic roundhouses from the mid to late first millennium BC (cf. Dun Bharabhat, Lewis; Harding & Dixon, 2000) through to the early to mid first millennium AD (cf. Scalloway, Shetland; Sharples, 1998). A variant of the general chronological schemes proposed by Parker Pearson & Sharples (1999) and Foster (1990) will be used in this study, without necessarily agreeing with the dates of occupation for certain site types inherent within the classification. Hence, the Iron Age is split into an Early (c. 700 cal BC - 100 cal BC), Middle (200 cal BC - cal AD 200), Late I (cal AD 100 - 600) and Late II (cal AD 500 – 900). The Norse period runs from approximately cal AD 900 - 1100, with no differentiation made for an initial Viking colonisation due to the rarity of excavated Norse period sites in the Western Isles. Each site block was assigned to these general periods to construct a basic chronological narrative in plant exploitation. The use of this more general chronology is in keeping with the amalgamation of relatively short phases, which cannot be separated by absolute dating, into the larger blocks.

4.3 The Calanais Archaeological Research Project (CARP)

All of the sites in this study were excavated under the wider umbrella of the Calanais Archaeological Research Project (CARP; Harding, 2000). A series of campaigns of survey and excavation has been part of this wider project, linked by the researchers association with the University of Edinburgh and the common base of Calanais Farm, the University's Archaeological Field Centre adjacent to the Calanais Stones (see Figure 3.1). The farm was purchased in 1985, with the dual intention of acting as a base from which projects could be run and also for experimental work on the farm itself. The research included growing six-row hulled barley for a season in two plots (Harding & Topping, 1986) and the experimental fire hearth project (Peters *et al.*, 2001; Church *et al.*, forth.), co-ordinated by the author and outlined in more detail in Chapter 5.

4.4 The Bhaltos Peninsula

The first research campaign focussed on the later prehistoric settlement of the Bhaltos Peninsula (see Figures 3.1 & 4.2). It is situated on the west coast of Lewis and contains most of the characteristic landscapes seen across Lewis and the Western Isles (Armit, 1994). The coast rises and falls to form a varied coastline of sandy beaches, machair, cliffs and low rock platform. Traigh Clibhe and Traigh Cnip are typical of the small beaches that are found along the west coast of Lewis. However, the wider machair of Traigh na Beirgh resembles the more continuous machair plain of the Uists, though on a much smaller scale. Much of the rest of the peninsula is made up of hills interspersed with small lochs. This topography prevents the formation of the widespread blanket bog that is prevalent across most of the interior of Lewis including the nearby Uig Peninsula. However, patches of well-humified deep peat are found within certain areas, such as small troughs and hollows.

While the landscape may have altered since the Iron Age, the elements from which it was comprised will have already been present. For example, the form and extent of the beach and machair of Traigh Cnip and Traigh na Beirgh will have varied, due to rising sea levels and the dynamic nature of the machair system. Geomorphic and bathymetric survey by researchers at the University of Edinburgh (Skinner, 1995; Dixon, pers. comm.) have shown that during the first half of the first millennium AD Loch na Beirgh would have been more extensive, with the site presumably surrounded by water. Also, the machair could have extended further seaward, with a eustatic sea level rise since the time of reconstruction in the order of 0.5 to 1 metre (Ritchie, 1985). In general however, we can assume that the landscape units were in broadly similar positions in the Mid to Late Iron Age to those of today.

The general Holocene vegetation history of the peninsula can be reconstructed through three pollen records from Loch na Beirgh (Lomax, 1997) and Loch Bharabhat (Lomax & Edwards, 2000). The Late glacial and Holocene profile from Loch Bharabhat was taken from the sediments and detrital mud of the loch (Figure 4.3). At approximately 3700 C^{14} BP (Bronze Age), a major loss of relatively mixed woodland occurred, with a rapid spread of heathland taxa and evidence of arable and pastoral activity within the catchment. Erosional disturbance of the catchment increased through the Late Bronze Age and Iron Age, presumably as a direct result of the islet occupation and associated settlement. A small rise in arboreal taxa, including Scots Pine (*Pinus sylvestris* L.), oak (*Quercus* sp.) and alder (*Alnus* sp.) occurred during the Mid to Late Iron Age. This tree pollen may have been secondarily derived from erosion of the surrounding soil (Lomax & Edwards, 2000) or may represent a localised copse or small extent of woodland within the catchment. The two profiles from Loch na Beirgh were taken from the infilled loch deposits adjacent to the islet on which the site is situated (Figure 4.4). No radiocarbon dates have been taken for the profiles but the chronological coverage is assumed to be contemporary with the site's occupation during the accumulation of the loch deposits of the first millennia BC and AD (Lomax, 1997). The catchment reflects the extra-local vegetation of the loch and encroaching machair, with the profile dominated by aquatic taxa and herbs of dry, light soils. Interestingly, there is also a significant proportion of barley (*Hordeum* type) pollen, with a marked correlation with pollen of the cabbage family (Brassicaceae), a theme explored in more detail in Section 7.2.

The first three sites excavated were found on the Bhaltos Peninsula. At the time of initial excavation, the sites were of particular interest because they were seen to represent the main Iron Age settlement forms common throughout the Western Isles. These included an 'island dun' at Dun Bharabhat, a 'broch' at Loch na Beirgh and the wheelhouse and cellular complex at Traigh Cnip (Harding & Armit, 1990). Excavation initially attempted to characterise the form and date of these structural forms with the eventual aim of comparing their structural, artefactual and ecofactual sequences to create an integrated socio-economic model for the area (cf. Ceron-Carrasco *et al.*, forth.). As discussed in Section 3.2.3, the sampling strategies for the three sites was not supervised by the author, until the final season at Loch na Beirgh (Church, 1996). Hence, deposits were sampled when the excavator deemed a context worthy of sampling, usually due to perceived ecofactual richness or archaeological importance of the deposit.

4.5 Dun Bharabhat

4.5.1 The excavated sequence

Dun Bharabhat (NGR: NB 098353) is located in a small loch within the hilly interior of the peninsula (see Figure 4.2). The islet was approached by a causeway leading out from the western shore of the loch (see Figure 4.5). Excavations, directed by Prof. Dennis Harding and Dr. Nick Dixon, concentrated on the 'dun' interior and an adjacent structure that had slumped into the loch and therefore required underwater investigation (Harding & Dixon, 2000). Only samples from the land-based excavations are included in this study, as the underwater material deserves detailed archaeobotanical analysis beyond the scope of this study (cf. Miller *et al.*, 1998). Also, the results would be difficult to compare statistically with the dry-land carbonised assemblages from the other sites.

It was clear after initial deturfing that the solid-walled dun was in actual fact a double-skinned roundhouse with many of the features, including galleries, intra-mural staircases and guard cells, that were traditionally used as criteria for brochs (Figure 4.5). Indeed, all of the later prehistoric roundhouses in the Western Isles excavated to date have had two, rather than one, drystone wall. This led Armit (1992) to reject the dun class in the Western Isles and incorporated such sites into his new Atlantic roundhouse classification. This simplified the later prehistoric structural diversity, allowing fresh approaches to be made to the settlement history of this period. It also meant that sites could be classified in more general terms through survey, with less ambiguity in the classification of the structural features.

The terrestrial structural sequence begins with ephemeral Early Iron Age activity (**DB-P**), before the construction of the complex Atlantic roundhouse (**DB-M**). This, in turn, was modified to form a simple cellular unit, which used the interior of the roundhouse and a remodelled gallery (**DB-S**). Radiocarbon dating of timbers in a destruction layer of the secondary occupation indicates the roundhouse was occupied within the second half of the first millennium BC. This destruction layer was readily identified during excavation and comprised thick deposits of interleaved orange ash, substantial fragments of charred timber and bands of carbonised material. Burnt bone and pottery were found throughout the horizon that covered nearly all of the internal space of the secondary occupation (Harding & Dixon 2000). Only judgement samples were taken (M Jones, 1991), including representative fragments of the charred timber and a single bulk sample (C.169) of carbonised material immediately overlying and interspersed with the timber. On analysis, this material was comprised entirely of barley straw (see Section 6.3.5 and Church, 2000). The most likely explanation for this horizon is that it represents the remains of a conflagration of the roof and organic superstructure. The timber fragments, some up to 0.6 m. in length, were radially orientated, the configuration expected for collapsed roof timbers (Gordon Thomas pers. comm.). It is likely that the barley straw represents part of the roofing thatch. The orange ash stems from the burning of peat or turf (Peters *et al.*, 2001), representing a further component of the roof material or flooring material burnt by the conflagration in a situation similar to that observed at Scalloway in Shetland (Carter, 1998b).

4.5.2 Chronology

Radiocarbon dates were obtained from charred timbers in the secondary occupation destruction layer and from a piece of uncarbonised wood from the ephemeral Early Iron Age activity underlying the roundhouse occupation (Table 4.1). These indicated that the roundhouse was occupied within the second half of the first millennium BC, with the occupation bracketed by a date from the pre-roundhouse levels of 2550±50bp (GU-2436) and two dates from the secondary occupation destruction layer of 2100±50bp (GU-2435) and 2010±50bp (GU-2434). When calibrated using OxCal (Version 3.5; Bronk-Ramsey, 2000 based on atmospheric data from Stuiver *et al.*, 1998) the dates do not extend later than the first century AD and could encompass a much earlier evaluation (Figure 4.6). These dates have important implications for the chronology of Iron Age settlement in the region. Firstly they have been used to demonstrate early secondary occupation of Atlantic roundhouses. More significantly, some researchers have seen these dates, in conjunction with the other date from the pre-roundhouse level, bracketing the construction and occupation of the complex Atlantic roundhouse to the mid to late first millennium BC (Armit, 1996; Harding & Dixon, 2000; Gilmour, forth.). This represents a considerably earlier date than the conventional assignment of these structures to the end of the first millennium BC and first millennium AD (cf. MacKie, 1971; Parker-Pearson & Sharples, 1999). However, a number of problems exist for this early dating. Firstly, three radiocarbon dates is a small number from which a site sequence can be proposed, let alone an important component of a revised framework for the region, a fact acknowledged by the excavators (Harding & Dixon 2000). Also, none of the dates are directly associated with the primary occupation of the roundhouse. However, this is a factor of the availability of sufficient material for the bulk radiocarbon dating employed a decade ago. The second major problem involves the material dated. The pre-roundhouse date came from a single piece of unidentified timber, whilst the two later dates again came from single pieces of timber, presumably of either Scots Pine (*Pinus sylvestris* L.) or spruce (*Picea* sp.) judging by the identifications made of comparable timber samples (see Section 6.3.5). Whilst avoiding the problems of bulk dating through the use of single entities (cf. Ashmore, 1999) the use of these timbers raises other problems. Firstly, timber would have been a very valued resource in the area by the Iron

Age. It can be envisaged that timber would be kept for as long as possible, with perhaps forms of curatorship and curing of the wood involving re-use over several generations. More significantly, the age range of the pine and spruce were at least 95 and 75 years respectively and none of these ring-counts represented the total age of the tree from heartwood to bark (Church, 2000). Furthermore, the spruce must have been driftwood and may have spent many years since point of death within the Atlantic, especially if derived from Siberia via the Arctic (Dickson, 1992). Therefore single entity dating of these timbers is not dating the point of conflagration. It is instead dating an accumulation of annual growth rings of trees that could have been over 100 years old and had died many decades before their final incorporation into the superstructure of the secondary occupation. This means the actual conflagration could have occurred at least a century or so later than indicated by the radiocarbon dates, a significant chronological adjustment in the context of Atlantic roundhouse development. Application for the AMS dating of barley caryopses from the main Atlantic roundhouse phase have therefore been submitted by the author to Historic Scotland to refine the chronology.

4.5.3 Sampling

15 *judgement* bulk samples and 19 routine samples for mineral magnetic analysis were taken from the three main blocks (see Tables 4.2 and 4.3). The single sample from the ephemeral activity underlying the roundhouse (**DB-P**) consisted of an occupation level. Three samples of occupation levels within the main roundhouse occupation (**DB-M**) were taken. A further six samples were taken from the secondary occupation (**DB-S**) including hearth material, cell fills and a single sample from the destruction level. Five charcoal samples were also taken from the burnt timbers in the destruction level. All of the samples were 5 litres or less in volume and a number of samples were of 0.5 litre volume or less that were only processed for mineral magnetic analysis. Following standardisation (Table 4.4), only one bulk sample from each of the three phases was included, a function of the small number of samples, the generic context types and the relatively small volume of the samples.

4.6 Cnip

4.6.1 The excavated sequence

The site of Cnip (NGR: NB 0985 3665) was first located at the back of Traigh Cnip on the Bhaltos Peninsula in 1988 (Figure 4.2), following severe erosion of the machair edge by winter storms. Dr. Ian Armit was invited by Historic Scotland to excavate the site in advance of further coastal erosion. Excavations revealed a multi-phase wheelhouse and cellular complex (Harding & Armit, 1990; Armit, 1996; Armit, forth.a). The structural sequence started with two adjoining wheelhouses (**CN-W**), one of which was incomplete (Figure 4.7). The internal furniture of the completed wheelhouse consisted of a central hearth, ephemeral stone partitions and various floor and occupation levels filling the central area and the bays. Few of these occupation, foundation and construction levels of the wheelhouses were excavated, as a sea-wall was built to protect the machair and the site by the time these levels were reached. The two wheelhouses were subsequently modified to create a sequence of cellular units (**CN-C**; Figure 4.8). These included remodelling of some of the bays of the completed wheelhouse and the construction of two new corbelled cells. These cells had revetted vertical slabs topped by corbelled horizontal coursing, a construction style also used at Loch na Beirgh during the Cellular Phase (LB-C). All of the cellular units had hearths and various occupation levels. These cellular units were in turn replaced by a substantial rectilinear structure (**CN-R**), which again used two of the earlier wheelhouse bays (Figure 4.9). The rectilinear building was separated into an outer and inner chamber with little occupation debris recovered from the outer chamber. The inner chamber and the re-used wheelhouse cells contained a number of floor levels and occupation levels.

4.6.2 Chronology

An extensive suite of radiocarbon dates was taken from the three main blocks that suggest the entire sequence was relatively short lived from possibly the 3rd century cal BC to the 2nd century cal AD (Armit, 1996; forth. a). The dating material chosen was almost exclusively bulk dates of cattle, deer and pig bone (Table 4.1 and Figure 4.6), introducing potential bulk and reservoir effect errors. Despite this, the Cellular (cal AD 1- cal AD 100) and Rectilinear (cal AD 100 – cal AD 250) secondary occupation blocks were tightly dated but larger errors were encountered from the material from the Wheelhouse block. Armit (1996, forth. a) therefore tentatively suggested a construction date of 3rd century cal BC for the complete wheelhouse to a 1st century cal BC accumulation for the later wheelhouse material. This represents a much earlier occupation than the early to mid first millennium AD occupation envisaged for Sollas (Campbell, 1991, 2000) and the various wheelhouses referred to by Parker Pearson and Sharples (1999) in South Uist. Again, it looks as if bulk dating of material potentially contaminated by old radiocarbon has fuelled the ongoing controversy of the dating and contemporaneity of the major Iron Age settlement types of the Western Isles (cf. Parker Pearson & Sharples, 1999; Armit, forth. b). Therefore, application for the AMS dating of barley caryopses from the main Wheelhouse phase have been submitted by the author to Historic Scotland to refine the chronology.

4.6.3 Sampling

44 *judgement* bulk samples and 37 routine samples were taken from the three main blocks (Tables 4.2 and 4.3). The full diversity of context types were sampled, with those types typical of domestic occupation, such as hearth material, ash spreads and floor levels, chosen preferentially. Again, all of these samples were small in volume, generally 5 litres or less. Following standardisation (Table 4.4), only three samples were included from the Wheelhouse block, one sample from the Cellular block and four samples from the Rectilinear block. This was a function of the small number of samples, the generic context types and the relatively small volume of the samples.

4.7 Loch na Beirgh

4.7.1 The excavated sequence

The final site examined on the Bhaltos Peninsula is the complex Atlantic roundhouse and secondary occupation at Loch na Beirgh (NGR: NB 1034 3516). The site was excavated over a period of 10 years from 1985 to 1995 by Prof. Dennis Harding and Dr. Simon Gilmour (Harding & Gilmour, 2000). It is situated towards the rear of Traigh na Beirgh (Figure 4.2), in a machair slack that has progressively silted up with windblown sand and organic deposits (Figure 4.4). During the Iron Age, this accumulation raised the level of the loch and resulted in successive superimposed phases of occupation within the structure, in an attempt by the inhabitants to maintain dry foundations. A sequence of deposits of over 2.5 metres has already been uncovered, with the primary levels of occupation of the secondary roundhouse and complex Atlantic roundhouse still to be excavated. Only a couple of the upper stratigraphic levels of the secondary roundhouse have been excavated and at this point the deposits displayed signs of almost permanent waterlogging and the concomitant preservation of organic material. Further excavation at the site will therefore represent a unique opportunity to investigate the organic components within an Atlantic roundhouse and its immediate secondary occupation.

The known structural sequence starts with the complex Atlantic roundhouse, followed by the construction of a substantial secondary roundhouse within the structure's interior (**LB-R**; Phase 10 in Figure 10). Few of the deposits associated with this phase were excavated, with only a large midden bulk sampled. There then appears a complex sequence of smaller cellular units, built with the now characteristic technique of slab revetting and horizontal coursing (**LB-C**; Phase 5 to 9 in Figure 4.10). The configuration of these cells was changed many times but the basic architectural concept was maintained throughout the phases. Central to the later Cellular phases (5-6) was an arrangement of two cells overlooking a forecourt with a hearth (Figure 4.11), which was reminiscent of the 'shamrock' recovered from Gurness in Orkney (Hedges, 1987). Associated with this 'shamrock' was a curved passage that was first built as a possible souterrain and re-used later as an entrance passage. A wide diversity of deposits were excavated throughout the Cellular phases including hearth material, ash spreads, middens, floor levels, foundation levels, occupation levels, cell fills, wall fills and negative feature fills. There then appears an intermediate phase of various truncated post holes and hearths, which seem not to make a coherent structural entity (**LB-I**; Phase 4). These are replaced in due course by two superimposed 'figure-of-eight' buildings (**LB-LIA**; Phases 1-3 in Figure 4.10) with the lower structure severely truncated by the construction of the much better preserved later structure. Both are reminiscent of the spatial configuration of a number of other Late Iron Age sites across Atlantic Scotland (Gilmour, 2000) including Buckquoy (Ritchie A, 1976), Dun Vulan (Parker Pearson & Sharples, 1999) and Bostadh (see below). The basic spatial organisation of these structures involves a relatively large cell with various internal furnishings, such as a central hearth, niches in the walls and ephemeral partitions, from which a smaller cell could be accessed. Again, a wide range of generic context types were recovered from the structures. A sequence of deposits, made up largely of wind blown sand, old ground surfaces and middens, was also recovered from a trench on the exterior of the broch. At the base of the external trench was the corner of a structure containing the usual range of occupation deposits. A number of paving levels and a possible jetty were also recovered from this and another external trench, presumably relating to various phases within the sequence in the interior of the site. The correlation to the internal phases was difficult because of the lack of direct stratigraphic links. Hence only a couple of the external deposits that had definite links (e.g. associated with paving through the entrance) were included in this analysis, an approach undertaken to avoid the problems experienced at Dun Vulan (see Section 4.2.2 above).

4.7.2 Chronology

A small number of radiocarbon dates have been processed from the secondary Roundhouse and Cellular phases (Table 4.1). These were processed prior to 1995 and so consisted of bulk charcoal dates and a bulk AMS date of barley grain. Despite this grouping of more than one single entity, all of the charcoal came from roundwood of fast-growing, locally-derived species from discrete charcoal concentrations sampled during excavation. This has created a relatively coherent chronology, backed up by artefact dating (Figures 4.6 and 4.12). The earliest date, calibrated to the early 2nd to the end of the 4th century cal AD, was derived from an occupation level on a flagstone floor of a first floor intramural gallery that was accessed during the later roundhouse phase. The other four dates, calibrated to the early third to the late 6th century cal AD, were processed from well-sealed points from the early to late Cellular phases. No radiocarbon dates have yet been processed for the later blocks in the sequence, but artefact typology of various diagnostic pieces places the 'figure-of-eight' structures from the 7th to the 9th centuries cal AD. Again, application for the AMS dating of barley caryopses from all of the phases has been submitted by the author to Historic Scotland to refine the chronology.

4.7.3 Sampling

The final season of excavation at Loch na Beirgh (1995) marked the first opportunity for the author to develop a statistically valid sampling strategy. This sampling strategy was based on *random* sampling of 20% of the sampled population (the contexts excavated), backed up by *judgement* sampling for certain contexts when deemed appropriate. Prior to this season, only *judgement* samples were taken. Nearly all of the contexts relating to the Cellular and Roundhouse phases and all of the external deposits were excavated in this final season and so only the samples from the later Intermediate and Late Iron Age 'figure-of-eight' are not statistically representative of the sampled population. In all, 37 *judgement* and 38 *random* bulk samples and 55 routine samples were taken (Tables 4.2 and 4.3). Again, the full range of generic context types were sampled, with the *judgement* samples a mix of cell and gallery fills and those types typical of domestic occupation, such as hearth material, ash spreads and floor levels. Many of these *judgement* samples were small in volume, generally five litres or less compared to the 28 to 56 litres taken in the final two seasons. Following standardisation (Table 4.4) only four samples remained from the Late Iron Age block and none at all from the intermediate block, due to the small number of samples, the generic context types and the small volume of the samples. Conversely, 20 samples from a sampled total of 45 remained from the Cellular block, demonstrating the effectiveness of the new sampling strategy. Only one sample was taken from the Roundhouse block, as very few contexts were excavated relating to this period.

4.8 Calanais kerb cairn

4.8.1 The excavated sequence

The kerb cairn near Calanais (NGR: NB 2179 3473) was excavated in 1995 in advance of road widening. The site was excavated by Tim Neighbour of the Centre for Field Archaeology (CFA), an applied unit part of the Department of Archaeology at the University of Edinburgh (Neighbour, 1997, 2001b). It was located within improved land comprising a wet organic sandy silt soil matrix and vegetation fit for rough grazing. Pollen sequences from Tob nan Leobag (3 km. to the south: Figure 4.13) and Loch na Beinne Beigge (2 km. to the east: Figure 4.13) suggest that by the third millennium BC the area was relatively open. Also the immediate landscape contained a significant proportion of agricultural land and encroaching heath (Edwards *et al*., 1994).

Three mains phases were identified, a series of negative features (**CC-1**: Figure 4.14) overlain by an old ground surface (**CC-2**) that was in turn truncated by the construction of the cairn (**CC-3**: Figure 4.15). The series of negative features have been tentatively interpreted as cremation platforms of Neolithic date (Neighbour, 2001b). The time elapsing between the abandonment of these platforms and the construction of the cairn was sufficient for a developed soil horizon to form (Carter, 2001). The cairn itself consisted of two kerbs enclosing multiple layers of burnt peaty turf ash and decomposed heathy plant material that made up the body of the cairn (Carter 2001; Milburn, 2001). A single stone cist was respected by these ash layers and contained a smashed urn that held the cremated remains of one, or perhaps two, individuals.

4.8.2 Chronology

Radiocarbon dating of eight barley grains from the ash layers created a relatively tight chronology from seven of the grains, placing the accumulation of the body of the cairn to the early to mid Bronze Age from approximately 1900 to 1500 cal BC (Table 4.1 and Figure 4.6). However, the vagaries of Atlantic Scottish dating were again exposed with the other grain dating from 2600 to 3000 cal BC. This may represent redeposited material from the earlier phases. However, this is difficult to assess as no material was processed from the old ground surface or the underlying negative features as very few plant macrofossils were recovered. The few degraded charcoal fragments and grain recovered from these negative features could have been be redeposited, therefore only providing a *terminus post quem* for the filling of the features and the development of the soil level.

4.8.3 Sampling

Though not present during the excavation, the author was consulted on the appropriate sampling strategy to be employed. Again a 20% *random* sampling strategy was employed, backed up by *judgement* samples from certain contexts such as the cist fill. 33 bulk samples and 49 routine samples were taken of only three context types, 1) the ash spreads that comprised the main body of the cairn, 2) the old ground surface and 3) several negative feature fills, largely from the pits and post holes underlying the old ground surface (Tables 4.2 and 4.3). A series of routine samples was also taken from a section through the ash spread and underlying material to assess, through mineral magnetic analysis, whether the material was dumped into the body of the cairn or burnt *in situ*. Following standardisation (Table 4.4), only 12 samples from the ash spreads within the cairn remained. All the samples from the negative features and the old ground surface contained fewer than 10 quantifiable components, a function of the macrofossil taphonomy and the small volume that could be taken from most of the negative feature fills.

4.9 Bostadh

4.9.1 The excavated sequence

A series of Iron Age and Norse structures were excavated from a small expanse of eroding machair at Bostadh, Great Bernera (NGR: NB 1373 4010; Figure 3.1). The site was directed by Tim Neighbour of the CFA and was funded by Historic Scotland and the University of Edinburgh in response to a renewed period of intensive coastal erosion of the machair (Neighbour & Burgess, 1997; Neighbour, 2001a). A large eroding section, over 30 metres in length and over 2.5 metres in height, highlighted the excellent structural, stratigraphic, artefactual and ecofactual preservation of the site prior to excavation. The initial remit of the project was to excavate all of the features. However, the priorities changed to those of characterisation and consolidation following the decision by the local council to build a sea wall to protect the site, the machair and the local graveyard approximately 20 metres back from the eroding edge. The fieldwork programme ran over 3 seasons of 4 weeks during 1996, excavating within an area of 20 metres by 30 metres, to a depth of up to 4 metres at the front of the trench. A complex sequence of very well preserved Iron Age and Norse structures and stratigraphy were revealed, from which tens of thousands of artefacts and ecofacts were retrieved. The post-excavation programme was of a significantly larger scale than any of the other sites within the study, including three fully funded PhD studentships provided by Historic Scotland for the analysis of the soil micromorphology, marine resources and terrestrial mammal bone assemblages.

The development of the settlement has been divided into four broad periods (Figures 4.16 and 4.17); the Early ephemeral structures (**BO-E**), a group of well-preserved 'figure-of-eight' houses (**BO-LIA**), a series of ephemeral features and middens filling the structures following their abandonment (**BO-**

LIA/N), all of which were overlain by an extensive Norse midden associated with part of a rectilinear building (**BO-N**). The ephemeral structures of the Early period were largely destroyed by coastal erosion or later construction, or in the case of Structure P only characterised before backfilling and the construction of the sea-wall. Structure P appeared to be roughly rectangular in plan and only the deposits immediately before post-abandonment were excavated. Structure J appeared to be the heavily eroded remains of a small cell within a larger structural unit that was subsequently incorporated with Structure H in a configuration reminiscent of the Rectilinear building at Cnip (Figure 4.16). Few deposits were demonstrably contemporary with these early structures as later occupation maintained the basic structural pattern and the earlier material was eroded or cleaned out.

The main period of the site consisted of three 'figure-of-eight' buildings (termed 'ventral' buildings by the excavator) revetted into the standing sand dunes with the full height of the walls preserved in most cases. This meant the interior furniture and deposits of the final occupation were protected by the post-abandonment deposits that filled these buildings. The buildings underwent significant renovation throughout this period but the basic structural configuration was maintained (Figure 4.16). It was very hard to demonstrate stratigraphic links between each of the sub-phases within the buildings, as the shells of the house effectively acted as large pits. However, it was possible to demonstrate that the construction of House 1 was later than House 2 as the head cell of House 1 utilised the pre-existing outer wall of the head cell of House 2. Whether this was days, years or decades later is impossible to tell, as the artefact assemblages from the three houses are remarkably similar (Neighbour, pers. comm.). Each of the houses maintained a basic pattern, with a central hearth within the larger cell along with a number of partitions, benches and niches representing the remains of internal furnishings (Figure 4.18). A range of deposits was associated with these occupation horizons including hearth material, ash spreads, floor levels and discrete middens. The occupation levels were only fully excavated in Houses 1 and 3; below these were a series of randomly placed negative features containing smashed pots, burnt material and unusual animal bones (Figure 4.19).

A period of post-abandonment accumulation of wind-blown sand and rubble then followed in which all of the 'figure-of-eight' houses were filled in. During this period (**BO-LIA/N**) ephemeral occupation deposits such as middens and a small structure within House 1 (Structure M; Figure 4.20) formed, marking occasional use of the site during the transition from Late Iron Age settlement to the Norse. The Norse settlement consisted of a large midden up to 0.3 m. deep that covered the wall heads of Houses 1 and 3. Part of a rectilinear structure (Structure A: Figure 4.17) was associated with this midden and contained a single floor level with no other surviving deposits or features. The structure survived with low wall footings of only a couple of courses at some points, suggesting the building was built largely of turf.

A full-scale replica of the House 3 'figure-of-eight' building was constructed about 200 m. from the original site in 1998 by Jim Crawford, a local stonemason. Important lessons were learnt in the construction including the efficiency of the wall construction and renovation (Neighbour & Crawford, 2001). This utilised the standing dune section, rather than re-deposited wall fill, between the two drystone walls that was observed during the excavations. It also proved possible to dismantle and reassemble stretches of walling without having to reinforce this wall material due to its inherent stability and compaction. No evidence of the roof was discovered during the excavation and after much discussion it was decided that a single rectilinear hipped roof would be built covering both cells simultaneously. In this way, two distinct arrangements of internal space were created; the 'figure-of-eight' lower floor and a single more expansive loft space akin to the rectilinear arrangement of Norse and later buildings. The replica house represents an important resource for future experimentation, testing hypotheses developed from the archaeological evidence.

4.9.2 Chronology

The early structures seem to relate to the early to mid first millennium AD; Structures J and P seem to have a cellular appearance, with slab-revetting and horizontal coursing that can be compared to Cnip and Loch na Beirgh Cellular phases (ranging from the 1st to 6th century cal AD). The structural configuration of Structure H and J is similar to that of the Rectilinear Block at Cnip (Figure 4.16), dating from the 2nd to 3rd centuries cal AD. This early to mid first millennium AD dating is supported by the small numbers of diagnostic pottery recovered from the early structures, including two sherds with wavy cordons from different vessels and a sherd incised with a ladder motif within the upper occupation level of Structure P.

Table 4.1 and Figure 4.6d present the 28 AMS dates processed from all the main phases from the Late Iron Age through to the Norse block. A remarkably short time period is represented with all of the dates falling within 700 - 1000 cal AD at 95% confidence levels. Unfortunately, within this calibration period there is a small radiocarbon plateau running from approximately 780-900 cal AD that means detailed chronological resolution between the different phases has not proved possible. However, the dating programme has confirmed that the main foundation and occupation phases of the three 'figure-of-eight' houses were contemporary, within the resolution afforded by radiocarbon dating at any rate. Therefore, the carbonised material recovered from each of the three houses can justifiably be amalgamated into one large block of analysis. The Late Iron Age block also marks an immediate pre-Norse settlement, with squatter activity and then a very early Norse phase in the form of the midden and the eroded rectilinear structure. This chronology covers the important Late Iron Age / Norse transition, an archaeological time period for which very little evidence has been recovered from elsewhere in the Atlantic West.

4.9.3 Sampling

The author was present for much of the first and final seasons of the excavations and an integrated sampling strategy for all ecofact types was designed from the outset. The backbone of this strategy was the *total* sampling of all coherent and undisturbed archaeological deposits, with volumes varying from 14 to 28 litres. These bulk samples contained carbonised plant macrofossils and charcoal, as well as the numerous shells and bones preserved in the alkaline machair sand. More detailed sampling was also undertaken to assess specific research questions. These included:

1) The dry sieving of the Norse midden and various floor levels to retrieve representative and sizeable bone and artefact assemblages from these important occupation levels. The dry-sieving was undertaken during excavation using 4mm gauge sieves and involved the sieving of 1 in 3 buckets of material from these extensive soil deposits. The carbonised plant macrofossils and charcoal recovered from this dry-sieving has not been quantified as much material would have been lost through the sieve. Archaeobotanical representation of these levels was undertaken through additional *total* samples taken.

2) The column sampling of certain floor and occupation levels for soil micromorphology to assess the deposition, erosion and post-deposition processes. A number of sections external to the structures were also column sampled to assess the 'natural' and anthropogenic amendment processes involved in the formation of a number of middens, wind blown sand levels and old ground surfaces.

3) *Interval* sampling of the final occupation levels within the House 3 complex, to assess any patterns in the distribution of geoarchaeological, ecofactual and artefactual material across the occupation level. These patterns were then interpreted in the light of recent discussions in the use of domestic space in Iron Age structures in Atlantic Scotland (cf. Parker Pearson & Sharples, 1999; Smith *et al.*, 2001; Milek, 2001) and ecofact taphonomy (see Section 5.3). The *interval* sampling involved taking samples of 1 litre volume on a 0.2 m grid from the upper occupation levels in Structures J, K and H, which were demonstrated to be contemporaneous through various inter-connecting sections. *In situ* magnetic susceptibility was measured using the Bartington MS2 field probe based on this 0.2 m. grid. A number of routine soil tests, including magnetic susceptibility, organic and inorganic phosphates and organic content, were measured from the bulk samples and the remainder of the sample wet-sieved to retrieve artefacts and ecofacts. Ecofact and artefact concentrations were then standardised by class per litre, with the values relevant to this study being carbonised quantifiable components per litre, burnt peat (mass in grammes) per litre and charcoal (mass in grammes) per litre. The values were then plotted using Autocad, a Windows based programme designed to extrapolate and present multiple gridded data sets (Young, 2002).

298 *total* bulk samples and 222 routine samples were taken from the four main blocks (Tables 4.2 and 4.3), with the full diversity of domestic context types sampled. Following standardisation (Table 4.4), 80 samples remained from the Late Iron Age block, 26 samples remained from the Late Iron Age / Norse block and 11 samples from the Norse block. Only one sample remained from the Early block, a function of the small number of samples and generic context types.

4.10 Uig Landscape Project

4.10.1 Research basis

A second major research project was initiated in 1995 by Chris Burgess, Dr. Simon Gilmour and the author investigating the settlement and environmental history of the Uig Peninsula, adjacent to the Bhaltos Peninsula in West Lewis (the Uig Landscape Survey; ULS). The project was designed to address a number of key research questions including:

1. To assess the settlement pattern within a relatively large area of coastal blanket bog. This would form the western survey unit within a much larger survey examining long-term settlement patterns around the sea lochs of the Loch Roags, including Great Bernera (Burgess, 2001), Calanais (Coles & Burgess, 1994; Burgess, 2001) and Garenin (Burgess *et al.*, 1995; Burgess, 2001). All of these area surveys were linked by the linear coastal erosion survey, grant aided by Historic Scotland (Burgess *et al.*, 1997a: Church & Burgess, in press).
2. To provide a comparative data set to that known from the adjacent Bhaltos peninsula (Armit, 1994). This would compare a number of data sets stemming from palaeoenvironmental and archaeological sites from the more marginal land of the Uig Peninsula to those from the machair and improved land of the Bhaltos Peninsula. Attention would focus on any archaeological evidence for the use of the Uig Peninsula as a hinterland zone for the excavated sites in Bhaltos, especially the later prehistoric sites outlined above.
3. To assess the long-term landscape and environmental history of the area, through the integration of on-site and off-site palaeoenvironmental proxies.

A four-year programme of fieldwork was designed consisting of two stages; 1) a landscape survey followed by 2) targeted excavation of specific sites. The initial landscape survey consisted of a walk-over survey of the whole of the Uig Peninsula and further areas around the machair fringing Camas Uig (Figure 3.1). A detailed coastal erosion assessment of all the machair and coastline in the study area was also undertaken. The survey located approximately 300 previously unrecorded sites, including over 30 of probable prehistoric date (Burgess & Church, 1996). From this survey, four sites were chosen for excavation due to their surface remains and landscape positions being different to the usual sites excavated across Atlantic Scotland at that time. For example, Gob Eirer was a promontory site with visible remains within the enclosure, An Dunan was a small islet site within estuarine saltings and Guinnerso was a substantial stone rich mound, with few discernible structural features visible within the rubble. Surveys across the Western Isles (Cowie, 1994; Coles & Burgess, 1995; Brannigan & Foster, 1995; Burgess, 2000, 2001; Church & Burgess, in press) had demonstrated the frequency of the classes of such remains and the lack of representative excavated sites that would allow more detailed interpretation of their date and function.

4.10.2 Palaeoenvironmental reconstruction

One of the key themes of the ULS project was the analysis of the nature and development of the environment in the Uig area throughout the Holocene. Specific attention was focused on the immediate environs of the sites excavated, and the way in which humans interacted with this landscape. This research has been carried out by a number of individuals on two principal scales;

firstly the regional scale that has focused on understanding the landscape change over many millennia and secondly on the site scale that has focused more on the integration, exploitation and manipulation of these landscapes by humans at specific times.

Turning first to the landscape evolution, a number of proxy records have been extracted from palaeoenvironmental sites dotted across the project area, which were first located by environmental survey. This survey was integrated with the archaeological monument survey and included coastal erosion assessment and targeted geomorphic mapping. The main focus of regional scale analysis was the loch basin and surrounding blacklands of Ruadh Guinnerso. Following exploratory coring in 1996, the basin was found to contain over 5m of laminated gyttja deposits, which had been exposed by the breaching of the loch basin by cliff retreat resulting from coastal erosion. A full profile was sampled for pollen and dating purposes (Flitcroft, 1997). The results pointed to a predominantly open heath landscape existing in the area for much the Holocene (Figure 4.21). This is in contrast to the profiles on the Bhaltos Peninsula, such as Loch Bharabhat (Edwards & Lomax, 2000), with its evidence of significant woodland cover until the Bronze Age. Hence, the profile is an important contribution to our emerging impression of a complex tapestry of habitats within the wider open landscape in Lewis. A series of peat monoliths have also been taken from eroding peat banks in the moorland surrounding the Guinnerso landscape, investigating past climate patterns through humification and tephra profiles. Initial results from both studies are very encouraging, with the emerging tephrochronology providing a tool for direct and very detailed comparison between the proxy records in the immediate area and beyond (Coles, in prep.).

The second scale of analysis centred on the environmental archaeological remains on the sites themselves. Of these, the largest assemblage from each of the sites was the carbonised plant material as the soil systems on the sites were generally acidic, negating the preservation of uncarbonised bone and shell.

4.11 Gob Eirer

4.11.1 The excavated sequence

Gob Eirer (NGR: NB 0315 3398) is a promontory fort situated on a small stack overlooking Camas Uig (Burgess *et al.*, 1997c; Church *et al.*, 1999). The sub-soil was a sandy material, possibly the remains of a nearby terminal moraine, into which a number of negative features were cut early in the history of the site. Ephemeral rigging was also noted, though no old ground surface was observed and all the negative features were filled with material relating to the main phase of the site. Excavations of this main phase revealed a thick drystone wall on the land-ward side of the stack with a small entrance in the centre of the wall. A cobbled path led from this entrance into the centre of the enclosed area to a partially excavated oval domestic structure (Figure 4.22). Inside the building a series of floor levels were recognised but appear to have been very disturbed and associated with a possible 'bench' feature. The building was interpreted as a domestic dwelling from the stratigraphy and range of artefacts, including pottery and coarse stone tools, found throughout the site. Later re-use added various levels of paving and at least two very ephemeral 'cell-like' structures, demarcated by alignments of larger rounded pebbles. Although structurally multiphase, the homogeneity of artefacts and other material found across the site, and the lack of later cobbling, paving or cells within the building, suggested a single general period of use (denoted **GE**).

4.11.2 Chronology

Four barley grains were submitted for radiocarbon dating, in an initial attempt to characterise the length of occupation at the site (Bronk Ramsey *et al.*, 2000). Two contexts were chosen, a fill of one of the underlying rigs and a foundation level for one of the later 'cell-like' structures, to bracket the main occupation of the site (Table 4.1 and Figure 4.6). The assays again highlighted the vagaries of radiocarbon dating, with the dates from the stratigraphically later foundation deposits providing slightly earlier dates than those from the rig fill. Also, all the dates fell within the first millennium BC radiocarbon plateaux complex already highlighted above. Therefore, for this analysis all the deposits from Gob Eirer have been assigned to one block dated from 900 to 400 cal BC. This chronology will be tested with the provision of further dates from the occupation of the main structure, though it is likely that the radiocarbon plateaux will make chronological accuracy difficult.

4.11.3 Sampling

The author was present throughout the excavations and a *total* sampling strategy was therefore implemented. 44 bulk samples and 49 routine samples were taken from a range of contexts, dominated by those types stemming from domestic occupation. Following standardisation (Table 4.4), 18 samples remained from the single site block.

4.12 An Dunan

4.12.1 The excavated sequence

An Dunan (NGR: NB 0445 3455) is an islet site located in a small area of saltings leading from Camas Uig. The main phase of the site (**AD-IA**) consisted of an elaborate central hearth with multiple ash levels *in situ*, some of which contained human bone (Figure 4.23). Large amounts of ash had spread from the hearth to form mixed floor levels contained within a D-shaped structure, with rubble walls reminiscent of burial cairn construction. A range of other furnishings and structural features were identified including a stepped feature controlling access to the hearth, a wide entrance to the west, an area of niches to the south and a clear area to the south-east. An intact shale bracelet was also found inserted into the fill of the north wall, probably representing a form of structured deposition. Initial interpretation of this structure highlights its specific role as a ceremonial site for human cremation, unique within the Atlantic Scottish Iron Age (Burgess *et al.*, 1997b, 1998a).

The upper layers of the underlying hearth were disturbed when a secondary building was inserted into the structure (**AD-M**). This structure was a 'dinghy' shaped building (pointed to the south and flat to the north) constructed of inserted orthostats and drystone coursing. It incorporated a stone bench feature to the south and was associated with a single floor that produced almost no finds. The function for this building is unknown, though a prosaic explanation is more likely than that proposed for the underlying structure.

4.12.2 Chronology

A total of 11 single entity samples were submitted for radiocarbon determination, seven samples from the underlying structure and four samples from deposits associated with the later inserted building (Table 4.1 and Figure 4.6). Six of the samples from the underlying building were single barley grains and one (OxA-8478) was half of a hazel nutshell, to check whether both of these single-year growth dating media were in agreement. One of the barley caryopses was also split for an auto-duplication exercise (Bronk Ramsey *et al.*, 2000), producing two radiocarbon determinations (OxA-8576, GU-8577). Almost inevitably, this exercise raised further doubts over radiocarbon dating providing tight chronologies. The centroids from the hazel nutshell and the barley grain from an ash spread within a floor level of the underlying building were 230 radiocarbon years apart. Moreover, the two auto-duplicate determinations from the single barley grain were also 195 radiocarbon years apart. Though this can be explained by a statistical probability, the eight determinations were derived from the best dating medium for the region, from what is essentially a single period of use in a building, but still only provide a chronological range from 400 cal BC to 100 cal AD!

The determinations from the inserted building are even less satisfactory, though this is a function of material and context selection. Two single entity radiocarbon samples from a large rhizome and a birch charcoal fragment were submitted from the single floor level in the structure. This plant material was chosen as no cereal grain was recovered from the context. The centroids were again over 150 radiocarbon years apart, providing a chronology from 1050 to 1400 cal AD. The other two dates came from barley grain from a fill overlying the floor level, one of which is clearly redeposited by worm action as it is less than 100 radiocarbon years old (OxA-8574).

4.12.3 Sampling

The author was present throughout the excavations and a *total* sampling strategy was therefore implemented. 91 bulk samples and 104 routine samples were taken from the Iron Age underlying building, consisting of a range of context types relating to construction, structural fills, the hearth and associated floor deposits and ash spreads. Following standardisation (Table 4.4), only 10 samples remained, reflecting the low frequency of quantifiable carbonised components within the building.

Eight bulk and routine samples were taken from the later structure dominated by cell fills. Following standardisation (Table 4.4), only three samples remained. Soil micromorphology samples were also taken through the hearth deposits and occupation levels of both phases to assess site formation processes.

4.13 Guinnerso

4.13.1 The excavated sequence

A multi-period relict landscape (NGR: NB 034 362) was discovered during the initial survey of the Uig area (Burgess & Church, 1996). It is situated within extensive blanket bog and peaty rankers topping high sea-cliffs, and comprised a series of features, including walls, cultivation rigs, cellular features, clearance and larger cairns radiating up to 250 m. from the partially drained Loch Ruadh Guinnerso. Their survival owes much to the remoteness of the site. To the south of the loch was a concentration of cellular structures on the saddle of a ridge. Three seasons of excavation focussed on this concentration (Burgess *et al.*, 1997d, 1998b; Church & Gilmour, 1999). Two main phases have been identified: a cellular complex of probable Mid Iron Age date and a later Medieval phase, with occupation of the main small double entranced structure radiocarbon dated to 15^{th} to 17^{th} centuries cal AD (Bronk Ramsey *et al.*, 2000). Analysis in this study is confined to the occupation deposits associated with the Iron Age structure and a rubble platform to the east of the structure (denoted **GUN-IA**; Figure 4.24). The main structure consisted of a number of ephemeral cellular units arranged around a central area containing a rectangular kerbed hearth. The structure was truncated by later activity in some places but a narrow entrance passage and vertical slabbing topped by horizontal coursing was evident in parts of the wall. Post-excavation analysis is still ongoing, though the initial interpretation proposes seasonal occupation, for specific economic activities such as transhumance.

4.13.2 Chronology

A suite of cereal grains will be submitted from the Iron Age levels from Guinnerso, as part of the 2002 tranche of Historic Scotland sponsored radiocarbon dates. However, the chronology of the earlier block is estimated to the Mid Iron Age (~200 cal BC to 200 cal AD). This chronology is based on structural typology (cellular building styles), coupled with artefact dating, that allows the block to be placed into the broad chronological resolution used within this study. A number of these pottery sherds contain elements within their decoration, such as incised decoration and applied bosses (Figure 4.25), that are comparable to elements within other dated pottery assemblages of the Mid Iron Age in the area, such as An Dunan, Dun Bharabhat and very early phases at Loch na Beirgh (Johnson, pers. comm.)

4.13.3 Sampling

The author was present throughout the excavations and a *total* sampling strategy was therefore implemented. 24 bulk and routine samples were taken from the occupation levels. Following standardisation (Table 4.4), 12 samples remained. Soil micromorphology samples were also taken through the hearth deposits and occupation levels to assess site formation processes. This was backed up by a number of routine samples taken at 2-cm intervals through the hearth material for detailed mineral magnetic analysis.

4.14 Galson

4.14.1 The excavated sequence

The machair edge at Galson (NGR: NB 436 594) has been eroding for decades (Cowie, 1994; Church & Burgess, in press) and has revealed a succession of archaeological remains. Limited sampling and recording has been conducted by Tim Neighbour of the CFA and the author at yearly intervals between 1996 and 2000 (Neighbour *et al.*, in press; Church, 1998; Peters *et al.*, 2000; Neighbour & Church, 2001). The work was conducted to characterise the archaeological remains and monitor the coastal erosion of the site on behalf of Historic Scotland. The remains can be broken down into two major levels in the eroding section. The first level comprises a number of Iron Age burial cists from an old ground surface that sporadically appears approximately half way up the section. The second level comprises domestic dwellings with associated palaeosols and middens of Iron Age to Medieval date on a higher level towards the top of the eroding section. The burial cists form part of an Iron Age cemetery, with the grave goods and radiocarbon dates pointing to the period of burial within a single horizon or OGS relating to the first half of the first millennium AD (Stevenson, 1954; Ponting & Bruce, 1990; Neighbour *et al.*, in press). The higher levels are less easy to define chronologically with many finds of Late Iron Age, Norse and Medieval date reputedly recovered from the upper horizons. Early excavations (Edwards, 1924; Baden-Powell & Elton, 1937) identified this upper level as one continuous midden, with the implicit assumption of single period deposition. However, it is clear from the range of structural forms and artefacts recovered from this layer, which is up to 4 m thick in some areas, that the level represents hundreds of years of accumulation and undoubtedly erosion.

A full section was drawn of the eroding features in 2000 (Figure 4.26), highlighting three main faces of eroding structures, largely within the upper level. Figure 4.27 shows the largest eroding face that contains both the cist level and the upper level. Within this upper level was a complex of structures (Structural complex B in the lower split section in Figure 4.27b) from which samples were taken from key horizons such as floor levels and middens. Figures 4.28 (Structural complex A) and 4.29 (Structural complex C) show two further eroding faces that contained eroding sections through structural complexes. Key horizons were again sampled. Structural entities are notoriously difficult to assess from complex stratigraphic sequences such as this and so a series of cereal grains were sent for AMS dating.

4.14.2 Chronology

Seven dates were produced from Structural complex B that ranged from 900 to 1350 cal AD (Table 4.1 and Figure 4.6). This shows that within this section the structural complex runs from the Norse to the Medieval period. A single date came from the floor level of Structural complex A, which placed the occupation of this cellular structure into the Late Iron Age between 200 – 400 cal AD. Three dates from Structural complex C ranged from 200 to 650 cal AD, again suggesting a Late Iron Age date. The 20 bulk samples taken from key floor levels and middens were therefore split into two general blocks, a Late Iron Age block from material from Structural complexes A and C (**GAL-LIA**) and a Norse / early Medieval block from Structural complex B (**GAL-N/M**). Though this amalgamated material that come from different structures, the separation of these structures on stratigraphic grounds is greatly complicated by the nature of the site. Also, many of the radiocarbon determinations overlap for the different levels, demonstrating a general period of use for different areas of the site.

4.14.3 Sampling

Sampling was conducted in three ways through the integrated use of soil micromorphology, routine and bulk soil samples and detailed mineral magnetic analysis of key archaeological deposits such as hearths, floors and middens. The sampling concentrated on the three main Structural complexes and included:

1) column sampling for soil micromorphology through floor levels in Structural complexes A (C.301 & 302) and B (C.205) and the large midden associated with Structural complex B (C.165).
2) close interval (2 cm.) routine soil sampling for mineral magnetic analysis through the interior and exterior deposits of Structural complex B (columns MS1 and MS2) and through the ash pit (C.400) in Structural complex C (column MS3).
3) 24 bulk and routine samples of the main floor levels, middens and hearths within the sequence for recovery of material for radiocarbon dating and other palaeoenvironmental analysis. This represented a form of *total* sampling of the generic occupation levels, with only representative routine samples taken from those context types rejected in the standardisation procedure. Four bulk samples were taken from the Late Iron Age levels (three floor levels from Structural complex A and one ash spread from ash pit in Structural complex C). Following standardisation (Table 4.4), only 2 samples remained. 20 bulk samples were taken from the Norse / early Medieval levels and following standardisation (Table 4.4), 10 samples remained.

4.15 Summary

This chapter has outlined the problems of dating within Atlantic Scotland. The problems can be split into two basic themes: interpreting the site stratigraphy and inconsistencies within radiocarbon dating. The first area includes the difficulties in linking contexts across multi-phase sites with a large stone component, complex secondary occupation and the concomitant truncation and redeposition of archaeological material. The potential errors associated with radiocarbon dating for Atlantic Scotland include the marine reservoir effect, bulk dating, the choice of dating medium, the radiocarbon plateaux and finally the statistical variability of the technique. A strategy was therefore designed to minimise some of the inherent problems within radiocarbon dating, through the dating of single entity cereal grains by AMS. However, it is clear that detailed dating chronologies are untenable at this stage and so the site blocks are assigned to five general periods within the first millennia BC and AD. A description of each of the nine sites was then given, outlining the research basis of the excavation, the excavated sequence and its chronology and finally the sampling details.

Chapter 5: Taphonomy

5.1 Introduction

This chapter will attempt to address the complex issue of archaeobotanical taphonomy in Atlantic Scotland. Efremov (1940) first introduced the phrase in his study of Eocene palaeontology and used the term to describe the formation and post-deposition processes acting on fossil beds. Since then, archaeologists have interpreted taphonomy as being the study of the post-depositional processes on an archaeological assemblage (Brain, 1981; Renfrew & Bahn, 1991) through to the appreciation of all the transformation processes that occur from the living assemblage through to the published archaeological report (Evans & O'Connor, 1999). In this study, the term taphonomy is used in its widest sense, including the investigation of both formation and post-deposition processes that shaped the final death assemblage.

5.2 Taphonomy and archaeobotany

Taphonomic studies in archaeobotany have concentrated on the transformation of the living cereal crop assemblage to the death assemblage, usually carbonised, that is recovered from the ground. The research has concentrated on the ethnographic observation of crop husbandry practices, processing stages and their identification in the archaeological record (Dennell, 1974, 1976; Hubbard, 1976; Hillman, 1981, 1984; Jones G, 1983, 1984, 1987, 1996; Charles *et al.*, 1997; Bogaard *et al.*, 1999; G Jones *et al.*, 2000). Hillman (1981) highlighted the various points of the processing when the products and residues could be exposed to fire and therefore preserve the remains through carbonisation. This carbonisation process is an important taphonomic filter as plant elements have been shown to vary in their preservation, depending on the fragility of the plant element and the environment of preservation (cf. Wilson, 1984; Boardman & Jones, 1990).

It has long been assumed both within Atlantic Scotland (cf. Milles, 1986; Bond, 1994; Dockrill *et al.*, 1994; Dickson, 1994; Holden & Boardman, 1998; Smith, 1999) and within Britain as a whole (Hillman, 1981; G Jones, 1984; M Jones, 1985, 1996; van der Veen, 1992) that much of the carbonised plant remains recovered from archaeological sites were most likely carbonised on household fires. A basic taphonomic model has been implicit within these studies. This involves three stages; 1) the pre-charring derivation of the plant material incorporated into the fires through direct or indirect human discard 2) the process of charring and carbonisation within the hearth itself and 3) the subsequent spread of ash from the hearth into the archaeological contexts sampled. The impression that most carbonised archaeobotanical assemblages in Britain are dominated by cereal remains (grain, chaff and weed seeds) has led to a tacit consensus that the major taphonomic input into these fires comes from the products and residues of this crop-processing (Greig, 1991; Jones, M 1996). This led van der Veen (1992, p81) to state "that carbonised seed assemblages (in Britain) consist largely of remains of harvested grain crops and their associated impurities".

In Atlantic Scotland, Milles (1986) first highlighted the probable position for carbonisation being the central hearth within the Neolithic houses at Scord of Brouster, Shetland. She then described the various taphonomic pathways through which the plant material could become incorporated into the hearth. Importantly, she stressed that crop-processing debris was only one of a number of sets of plant material that was carbonised in the hearth. Bond (1994, 1998) and Dockrill *et al.* (1994) also highlighted the various taphonomic pathways leading to the archaeobotanical assemblages at the multi-period sites at Pool and Tofts Ness in Orkney, again stressing that crop-processing products and debris were only a proportion of the plant material incorporated into domestic hearths. Ethnoarchaeological research by Smith (1994, 1996) on an abandoned 20th century croft at Howmore, South Uist demonstrated that the largest concentration of carbonised remains recovered came from the byre, representing the use of accidentally burnt cereal remains from a kiln that were subsequently used as bedding for calves. These studies demonstrate the taphonomic complexity in Atlantic Scotland and help to explain the background to one of the major research problems of this study.

5.3 The taphonomic research problem

The basic research problem is simple and will be familiar to many environmental archaeologists working in Atlantic Scotland and the North Atlantic in general. If you take a bulk sample from a midden, wet sieve it and then identify the carbonised plant macrofossils that are recovered, it becomes immediately apparent that an admixture of plant communities and habitats is present. For example, a typical midden sample from the Iron Age levels at the Howe in Orkney (Dickson, 1994) or Dun Vulan, South Uist (Smith, 1999) usually contains a mix of 1) barley with 2) possible weeds of cultivation, 3) species from moorland and blanket bog, such as heather and sedges, 4) seaweed and 5) even aquatic plants, such as rushes. This is also true of many of the samples analysed in this study (see Section 6.3). Clearly, all these plants could not grow together and so represent a complex process of taphonomy leading to the archaeological deposit.

There is an implicit, but rarely stated, assumption within archaeobotanical reports from domestic structures in the region that most of the plant macrofossils become carbonised in the hearths and are then spread by various taphonomic pathways to the archaeological deposits that are sampled (cf. Milles, 1986). However, this basic taphonomic model has rarely been demonstrated through an independent proxy record. It is with this research problem in mind that mineral magnetic measurements were taken for each routine sample and profiles through key sections (see Chapters 3 and 4). To recap, preliminary mineral magnetic analysis by the author of on-site archaeological sediment from the Cellular phase at Loch na Beirgh (Church, 1996), showed marked magnetic enhancement of certain generic context types with a significant ash component, such as hearth material, ash spreads and middens (Figure 5.1). It was also noted that the samples with marked magnetic enhancement could contain high concentrations of carbonised plant macrofossils, establishing the link between the spread of ash and plant material across the site. A preliminary level of analysis was designed to answer a number of basic research questions including:

1) Was the magnetic enhancement observed at Loch na Beirgh repeated at the other sites?
2) Was this magnetic enhancement largely the product of the spread of ash from hearths?
3) Is there a link between magnetic enhancement, ash content and carbonised plant macrofossil concentration and was this repeated across the sites?

It was envisaged that the results from these questions might provide the basis for an independent proxy to test the taphonomic model outlined above.

5.4 Testing the model

Table 4.3 shows the number of samples analysed for mineral magnetic analysis and the breakdown of generic context types analysed for each block. The breakdown reflects the stratigraphic and functional character of the block, with greater variety generally displayed by the sites with a predominantly domestic function. For example, the three structural complexes within the machair (Cnip, Galson and Bostadh) have a wide variety of context types such as hearth material, ash spreads, floor levels and middens. Conversely, Calanais kerb cairn only has three context types (ash spread, negative feature fill and old ground surface) reflecting the three principal sets of features on this funerary site. The mineral magnetic results (Table 5.1) are discussed with reference to the three research questions outlined above.

1. Was the magnetic enhancement observed at Loch na Beirgh repeated at the other sites?

Figure 5.2 presents the χ readings from all the samples, from the lowest to the highest values in order, from each block. Table 5.2 shows a selection of control values for the surrounding 'natural' soil matrix for most of the sites. When comparing the 'natural' and archaeological values, it can be seen that the magnetic enhancement observed at Loch na Beirgh is repeated at all of the sites, except for Gob Eirer. However, a wide variability is observed between the general profiles of each block. This is dependent largely on the site formation processes and the breakdown of the generic context types that make up the site. For example, most of the contexts sampled from An Dunan have marked magnetic enhancement, whereas over half of the samples from Bostadh have relatively low magnetic concentration, a disparity that can be explained by the generic context types sampled from the two sites. An Dunan consisted of mostly hearth material, ash spreads, floor levels, occupation levels and cell fills with a significant ash component where as the Bostadh samples with low χ values consisted of various contexts types, such as cell and wall fills, which were almost 100% machair sand. Also, only limited enhancement was observed from the two blocks underlying the cairn at Calanais (**CC-1** and **CC-2**; Figure 5.4), the later structure at An Dunan (**AD-M**) and the earliest block at Bostadh (**BO-E**). This was again a function of the context types sampled with the underlying blocks at Calanais consisting of negative features filled by the later old ground surface and the few samples from the earliest block at Bostadh and the later block at An Dunan consisting of largely sterile cell fills. The one site where magnetic enhancement was not seen despite the presence of other occupation material was Gob Eirer, with only one sample from an occupation level with significant magnetic concentration. At this site, post-depositional processes that altered the magnetic properties of the soil, principally localised waterlogging, led to the dissolution of the mineral grains and their removal by leaching. Subsequent re-deposition in the form of extensive iron pan deposits was observed across the site. In view of this, the magnetic data from Gob Eirer has not been used in further analysis.

2. Was this magnetic enhancement largely the product of the spread of ash from hearths?

To answer this question, we need first to demonstrate magnetic enhancement in samples from hearth material and associated ash spreads. Figure 5.3 presents the samples from all the sites (except for Gob Eirer) grouped by context type and arranged in order of increasing χ. Samples from hearth material and ash spreads are seen to undergo significant enhancement. More variable values are recorded for cell fills, floor levels, middens, negative feature fills, occupation levels and wall fills. It is proposed that this variation is related to the proportion of ash within the deposit. For example, the negative features underlying the old ground surface at Calanais kerb cairn have relatively low χ values (Figure 5.4) with little ash content from the excavation records. Conversely, the negative features within Loch na Beirgh contained variable proportions of ash on excavation, which is demonstrated in the laboratory by the more variable χ values (Figure 5.1). The context types with generally low χ values (e.g. old ground surfaces and wind blown sand) by their very nature have relatively little ash in their composition. However, slight magnetic enhancement in these last mentioned context types has been used to demonstrate soil amendment strategies elsewhere in Atlantic Scotland (cf. Dockrill & Simpson, 1994; Batt & Dockrill, 1998).

The series of close-interval (2 cm) mineral magnetic profiles also confirmed this correlation between magnetic enhancement, ash content and occupation levels through key sections at some of the sites. At Galson (Peters *et al.*, 2000), three profiles were taken through the interior (MS1) and exterior (MS2) of a Norse building within Structural complex B (Figure 5.5) and a third profile (MS3) through a pit full of orangey yellow ash within Structural complex C (Figure 5.6). Both MS1 and MS2 show marked magnetic enhancement corresponding to a clear floor level and thick organic midden respectively. Soil micromorphology undertaken on both levels has shown that ash forms a significant component of the matrix of both contexts compared to the other deposits (Tams, pers. comm.). In both profiles, the lowest context (C.159) represents the 'natural' sand and further limited enhancement of the higher middens (C.140 and C.157) can be seen. Indeed, the similarity in the profiles from C.203 upward demonstrates that mineral magnetic profiles could be used to correlate contexts across eroding sections. Much of the third profile (MS3) was made up of pure ash and therefore displays very high χ values. The dramatic decrease in χ values at the top and bottom of the profile represent sampling of the underlying 'natural' and post-abandonment wind blown sand respectively. Marked mineral magnetic enhancement was also noted from the close-interval sampling of the rectilinear hearth at Guinnerso (Figure 5.7 based on data from Mitchell, 1998 and Peters *et al.*, 2001). A profile was also taken through the ash spread within the body of the cairn at Calanais (Figure 5.8). The enhancement was confirmed by the χ values from the routine samples of the ash spread compared to those from the underlying deposits (Figure 5.4).

This enhancement can also be viewed in plan from the floor sampling exercise at Bostadh (Figure 5.9). Mineral magnetic enhancement occurs in two areas that correspond with ash spreads observed during excavation. These ash spreads presumably relate to the spread of ash from the central hearth and may represent spillage of ash that was being taken from the hearth to an external midden. Also, the movement of people and animals around the hearth would spread ash around the central area and out through the entrance to the south-west. The enhancement in the north-west of the floor may represent an isolated ash dump.

We can therefore assume that the magnetic enhancement in most context types seems to stem from the spread of ash from hearths or other burning activities, evidence for which is usually recovered during the excavation. Further information on the domain state of the magnetic material can be gained from plotting χ against κ_{fd} for each of the samples with κ_{lf} values of 100 or greater. The cut off point was chosen as material with a weak magnetic signal ($\kappa_{lf} < 100$) is more likely to give incorrect κ_{fd} values (Dearing, 1994). Figure 5.10 presents 221 samples from all of the sites plotted in this way. All of the samples from the ash pit at Galson (MS3) and the hearth from Guinnerso have also been plotted (Figure 5.11). Most of the samples plot between 6 and 10 % for κ_{fd}, meaning a sizeable proportion of the magnetic domain state is made up of superparamagnetic grains, a consistent magnetic signal most likely explained by the ash being produced from a similar burning process and/or fuel source (see below).

3. Is there a link between magnetic enhancement, ash content and carbonised plant macrofossil concentration and was it repeated across the sites?

To test this hypothesis, we can analyse the relationship of magnetic enhancement (χ) and macrofossil concentration (QC/litre) on a site by site basis. Figure 5.9 presents the χ, QC/litre and charcoal weight / litre for the floor grid at Bostadh. Significant concentrations of plant macrofossils and charcoal are only observed within areas of magnetic enhancement that relate to ash spreads. Figure 5.8 presents data from Calanais kerb cairn as a further example. It can be seen that the negative feature fills and old ground surface underlying the cairn have relatively low χ and QC/litre values whereas the ash spreads that comprise a large part of the body of the cairn display significant magnetic enhancement and concomitant increased macrofossil concentration. In both examples, the increase in macrofossil concentration is not proportionally related to an increase in the magnetic susceptibility. Instead, a threshold in magnetic susceptibility, and therefore ash content, is reached beyond which significant levels of plant macrofossils can be recovered.

This threshold concept can be demonstrated across the rest of the sites by grouping samples into classes of increasing χlf and calculating the mean and median QC/litre for each class (Table 5.3). The results are plotted for each χ class midpoint in Figure 5.12. Again, this shows that there are low QC/litre values for the weaker χ classes up to 0.5 $\mu m^3 kg^{-1}$, the threshold beyond which significant macrofossil concentration can be observed. A difference in magnitude can be seen between the mean and median QC/litre for each class, demonstrating the variation in macrofossil concentration for each class with both low and high QC/litre values possible beyond this threshold. However, very few samples with significant macrofossil concentration have weak magnetic signals. Therefore, in general it can be proposed that significant carbonised plant macrofossil concentration within an archaeological deposit within the study area correlates to a significant magnetic enhancement stemming from the input of ash into the context. This input of ash into a sediment can therefore be proposed as the primary taphonomic pathway for archaeobotanical material into that deposit.

It is clear that ash is widespread across most Atlantic Scottish sites and that various processes contribute to the spread of the material. In this way, ash and carbonised material become mixed and it is possible to estimate the potential for mixing by looking at the generic context type of a deposit. We could call this potential for mixing 'taphonomic heterogeneity'. A high degree of 'taphonomic heterogeneity' means that a plant macrofossil assemblage could have accumulated through a number of taphonomic pathways. Conversely, a low degree of 'taphonomic heterogeneity' means an assemblage was deposited from a low number of taphonomic pathways. This is important as it governs the degree to which a certain assemblage can be used to reconstruct behavioural episodes, as defined by G Jones (1991). Within the generic contexts used in this study, only hearth material and ash rich spreads can be said to have a low 'taphonomic heterogeneity' as they stem from what are essentially single behavioural episodes of burning within the hearths. However, all the other context types will have an unknown number of taphonomic pathways leading into them, each spreading the ash and macrofossils across the site. This is particularly acute for deposits such as occupation levels, floor levels and middens.

A general model of archaeobotanical taphonomy can therefore be proposed for the seven essentially domestic and two probable funerary sites within the study area. Several *in situ* hearths were recovered from each of the domestic sites and the associated hearth material and adjacent ash spreads displayed marked magnetic enhancement with variable carbonised macrofossil concentrations. These deposits have a low 'taphonomic heterogeneity'. The subsequent spread of this ash, through various human, accidental or natural processes, can also be demonstrated through magnetic enhancement of associated archaeological deposits, such as floor levels and middens. These deposits have a high 'taphonomic heterogeneity'. In this way, a large proportion of the macrofossils recovered from an archaeological phase would have ultimately been carbonised in the hearth(s) within the structure. These hearths act as a carbonising point for plant material that become incorporated into the fire and ash, whether deliberately as kindling or fuel or accidentally through an unknown number of variable human and natural processes. The two funerary sites investigated also showed the correlation of magnetic enhancement, ash input and macrofossil concentration. However, it is likely that the ash in these would have been produced through potentially different burning episodes and processes than those occurring in a domestic hearth. The consistently high proportion of superparamagnetic grains within the domain state profile of most of the samples strengthens the impression of a similarity of burning process producing the ash.

5.5 Experimental fire hearth research basis

However, it is clear that an investigation of the carbonisation processes within hearths would greatly enhance our understanding of archaeobotanical taphonomy. Therefore, a programme of experimental archaeology was designed to investigate the processes of carbonisation in replica hearths and the residues produced.

Investigating the types of fuel used was seen as a key research theme for a number of reasons. Firstly, fuel procurement is an important research question within the study area in its own right (Armit, 1996; Dickson, 1998; Carter, 1998a). Timber would have been a valued resource as tree cover throughout the Western Isles was greatly reduced by the Iron Age (Birks, 1994; Fossit, 1996; Brayshay & Edwards, 1996; Lomax, 1997). Therefore, the use of branchwood would have been reserved for internal structural furnishings and tools and rarely used for fuel. Other fuels would have been burnt and their gathering would have been an important component of the annual resource procurement strategy.

Secondly, the admixture of plant ecologies within typical archaeobotanical assemblages in Atlantic Scotland may be a function of contamination from the fuel from the hearth in which the plant macrofossils were carbonised. Past research has shown that certain fuels introduce plant macrofossils from their primary ecosystems, for example from the grassland and heaths from cut turf (McClaughlin, 1980; Bottema, 1984; Dickson, 1994, 1998) and pasture represented in dung used as fuel (Miller & Smart, 1984; Anderson & Ertug-Yaras, 1998; Charles, 1998; Smith, 1998). A basic research question was therefore developed with the primary aim of assessing the amount of contamination from different fuel sources and developing independent proxies to source the fuel. Proxy records independent of the archaeobotanical assemblage are needed to allow the separation of those plant macrofossil that could be fuel contamination from those macrofossils relating to other human behaviour. It was clear that mineral magnetism could be used as an independent proxy as there was demonstrable magnetic enhancement with ash on the archaeological sites within the study area. Also, the consistent magnetic signal from the κ_{fd} of the archaeological material (Figure 5.10 & 5.11) may indicate a similar burning process and/or fuel source. Finally, past researchers (Oldfield *et al.*, 1981; McClean & Kean, 1993; Linford, 2000) have shown that materials burnt under experimental conditions had subtle but detectable magnetic differences.

Past research (Carter, 1998a, 1999) has also shown that soil micromorphology can source certain fuels in Atlantic Scotland, such as peat and turf. Adrian Tams, a post-graduate in the Department of Archaeology at the University of Edinburgh, has been investigating the soil micromorphological characteristics of the experimental fire hearths and comparing the profiles to those from hearths and floor levels at Bostadh, An Dunan, Guinnerso and Galson. The results from his research are used to corroborate patterns observed from the mineral magnetic data.

5.6 Experimental fire hearth methodology

5.6.1 The fuel types

The choice of fuel sources for the experimentation was based on past research conducted on various sites in Atlantic Scotland. The techniques used included on-site archaeological observation of peat stacks and ash (cf. Harding & Gilmour, 2000), archaeobotanical analysis (cf. Dickson, 1994, 1998; Boardman, 1995a; Smith, 1999) and soil micromorphology (cf. Carter, 1998a, 1999; Schwenninger, 1999). Ethnographic observations (Martin, 1716; Fenton, 1978) and discussions with local people who still cut peat from their township peat banks also built up a picture of the fuel types used in the recent past. Four main fuel types were apparent from these various lines of evidence; 1) well-humified peat from the large tracts of blanket bog that covered the interior of Lewis for thousands of years (Birks, 1994; Fossit, 1996; Brayshay & Edwards, 1996; Lomax, 1997) 2) peaty turf and 3) fibrous peat from the more shallow peat, usually found in the narrow coastal strip in which most of the archaeological sites and modern settlements are found and 4) wood, including locally derived small roundwood as well as timber driftwood (Dickson, 1992). Other types of fuel could also have been used including dung, seaweed, straw/hay and other types of organic turf. However, it was felt that the four main fuel types outlined above would form the first phase of the experimentation, with further burning of the other possible fuel types at a later date. Clearly, the mineral magnetic signatures of these other fuels may overlap with the four main types. However, archaeobotanical evidence of these other fuel types, such as burnt seaweed, were rarely found on the sites investigated on Lewis.

5.6.2 Field methodology

Three replica hearths were constructed at Calanais Farm, based on the Late Iron Age three-sided hearths commonly uncovered in the Western Isle of Scotland (cf. Chapter 4 in Harding & Gilmour, 2000). Each hearth measured approximately 0.6 x 0.4 m and was designed on the basis of the hearths excavated at Bostadh (Neighbour, 2001a). The hearth slabs consisted of Lewisian gneiss, the basement local rock for much of Lewis, and they were placed into approximately 0.1 m of magnetically sterile sand from the beach at Bostadh.

The fuel was taken from two areas; the peat turf and fibrous-upper peat from near the township of Gearranan (NGR: NB 205 445) and the well-humified peat and wood from near Gearraidh na h-Aibhne (NGR: NB 265 307). All the peat types were cut in springtime and dried and stacked in the summer. The wood came from dead pine trees (*Pinus* sp.) from a plantation recently blighted by beetles. Generally, a single fuel type was burnt in each replica hearth for a 72-hour period, which allowed for the construction, burning and sampling of a single hearth in one week. The fires were started by lighting lichen (*Ramalina* sp.) and pine wood chips (*Pinus* sp.) before adding the selected fuel. 18 fire hearth runs were undertaken in total (FH1 to FH18). Table 5.4 lists the individual fire hearth runs, the fuel types and samples used for mineral magnetic sourcing outlined below. Temperature profiles were going to be taken at various intervals using a pyrometer, but the tip of the sensor melted on the first measurement within the core of well-humified peat burning in FH1! The temperature had reached 900 °C before meltdown and it was not possible to locate another pyrometer or thermocouple during the field season. No attempt was made to monitor the atmospheric environment of the burning, as the experimentation was undertaken to replicate human action rather than exact laboratory conditions. Following the burning, the hearths were allowed to cool before sampling. The colour of the ash produced was first recorded *in situ* using a Munsell colour chart (1992). Multiple samples were then taken for mineral magnetic measurements, soil micromorphology and archaeobotanical remains. The samples for mineral magnetic analysis were taken firstly on a grid basis of 0.2-m intervals from both inside and outside the hearth. A section line was then set up through the hearth and half the ash excavated. Bulk and routine samples were taken for archaeobotanical and mineral magnetic analysis respectively. The section was then drawn for each hearth sampled (see Figure 5.13) and in some cases close-interval (2 cm) samples taken through the ash and the underlying sand. Kubiena tins were also taken from hearths with single fuel types, for soil micromorphological analysis. The rest of the ash was then excavated and the ash from each fuel type dumped onto specially prepared areas covered by sterile beach sand, located in a sheltered area in Calanais farm. These dumps were sampled in the summer of 2000 and further sampling is planned for 2003 (five years after the initial dumping) to assess issues of ash spread and midden formation, exposure and erosion and any short-term modification in the magnetic properties of the material.

5.6.3 Bulk sample processing and macrofossil identification

The bulk samples were wet-sieved in the laboratory (Kenward *et al*., 1980) and the flots and residues air-dried. Both were then sorted following the same methodology as the archaeological samples. All carbonised plant macrofossils were identified where possible and quantified following the same criteria as the archaeological material. Charcoal identifications were made on carbonised fragments of <4 mm diameter. The total fragments and weight from both the flot and residue from each sample were calculated. Up to 20 fragments were then randomly chosen for identification from the flot, using a riffle box, random number tables and a 2D grid.

5.6.4 Mineral magnetic measurements and quantification

The mineral magnetic analysis was undertaken in collaboration with Dr. Clare Peters, a research fellow in the Department of Chemistry at the University of Edinburgh. Callum Mitchell supervised the experimental fire hearths as part of his undergraduate dissertation from the Department of Archaeology at the University of Edinburgh (Mitchell, 1998). MC and CM processed all of the mineral magnetic values from the experimental fire hearths. CP and MC then undertook the quantification of the results. CP undertook the high temperature susceptibilities. MC and CP processed the detailed mineral magnetic measurements from the hearth material and ash spreads from the archaeological samples.

Samples of the ash were taken from both the routine sampling of the ash from each hearth and the close-interval samples from selected hearths. These were then dried for 24 hours at 40°C, before being sieved through a 63µm gauge. The sieving was undertaken to isolate mechanically the ash component and to remove larger clasts, particularly important when analysing archaeological samples. A short test was designed to gauge the optimum sieve size, in terms of efficiency and magnetic concentration, needed to isolate the ash component. A bulk sample of well-humified peat ash (S.96) was taken from FH13, dried for 24 hours at 40°C and split in two using a riffle box. The two sub-samples (A & B) were then passed through a sieve stack of standard Phi intervals from 1000 to 63 µm, the ash being agitated by a sieve shaker for 15 minutes. The 63 µm sieve was the smallest sieve chosen as little of the ash conglomerates passed through smaller gauges. Figure 5.14 shows that the material below 63 µm had the highest magnetic concentration, reflecting the high proportion of ash. The <63 µm fraction was therefore chosen for the detailed analysis outlined below.

Six room temperature magnetic measurements were carried out on the modern ash residues of known fuel type. These included:

i) susceptibilities at low and high frequencies measured using a Bartington MS2 susceptibility bridge.

ii) anhysteretic remanent magnetisations (ARMs) grown using an adapted Molyneux AC Demagnetizer and measured using a Molspin fluxgate magnetometer. Two measurements were made for each sample; the saturation (S)ARM was grown in a peak alternating field of 99 mT superimposed on a direct field of 0.5 mT and subsequent demagnetisation of SARM in an alternating field of 40 mT.

iii) isothermal remanent magnetisations (IRMs) grown using a Molyneux pulse magnetiser and electromagnets and measured using a Molspin fluxgate magnetometer. The IRMs were grown in two fields of 60 mT and the saturation (S) IRM in 1 T.

The following magnetic parameters were determined from the six measurements for each sample: specific susceptibility (χ), frequency dependent susceptibility (κ_{fd}), specific SARM, specific SIRM and the ratios $ARM_{demag40mT}/SARM$, $IRM_{60mT}/SIRM$, SARM/χ, SARM/SIRM and SIRM/χ (Table 5.5). Further details of the procedures and applications of these mineral magnetic measurements and ratios can be found in Thompson & Oldfield (1986), Walden *et al.* (1999), Maher & Thompson (1999) and Peters *et al.* (forth. a).

5.7 Fire hearth results

5.7.1 Observations on ash production

Differences between the fuel types were observed during the burning periods. These observations will be discussed for each fuel type in terms of qualitative (burning characteristics including rate of fuel consumption and smoke production) and quantitative (Munsell colour and volume for ash produced) differences.

Turning first to the qualitative differences, well humified peat burnt very well, producing an even and powerful heat (FH1,4,7,10,13,16). Small flames could sometimes be seen and the fire could be left unattended for a couple of hours before needing more fuel. Smoke emission was low and caused no discomfort to the eyes and throat. The fibrous upper peat appeared only to smoulder with no visible flames and emitted very little heat (FH2,5,8,11,14). The combustion occurred within the core of the fire and this meant the fire could be left unattended for over seven hours before needing fuel. Very little smoke was produced and again it caused no discomfort. Peaty turf generally acted in a similar manner to fibrous upper peat, except that the fires burnt at a faster rate, needing refuelling every four hours, and therefore produced a more consistently powerful heat (FH9,17). The wood fires burnt very quickly producing a powerful heat immediately on ignition (FH3,6,12). However, a wood fire would need almost constant attention and could be left unattended for only about half an hour. A lot of smoke was generally produced and was more irritable to the eyes and throat than the other main fuel types. Seaweed and straw were also burnt within the mixed fire hearths (FH15 and FH18) and both burnt very quickly, producing very little ash. The seaweed produced a very dark, acrid smoke that would have been very unpleasant if burnt within a confined area. The smoke from the straw was similar but less overpowering (summarised from Mitchell, 1998).

Table 5.4 presents the Munsell colours and the volumes of the ash produced by each of the fire hearths. It can be seen that each fuel type created a certain colour range of ash with the well-humified peat producing reddish/yellow ash, whilst the fibrous upper peat and peaty turf produced ash of a much darker red colour. The ash from wood, straw and seaweed was much lighter in colour, ranging from grey to white. Superficially, this may suggest that the colour of archaeological ash could be the first clue to the fuel source but caution must be exercised in using this approach as the colour is as likely to be governed by the atmospheric conditions during the burning and post-deposition processes as the fuel source (Carter, 1998a, 1999). Of more archaeological relevance is the difference in ash volume produced by the fuel sources. The amount of fuel put onto each fire was not recorded and the volume measurements take no account of compaction differences so accurate differences are hard to quantify. However, it is obvious from the volume measurements and observation during the burning that the peat and turf produced significantly more ash than the wood, straw and seaweed. Indeed, despite burning at least a young pine tree on each wood fire very little ash was left. Conversely, the peat fires were generally overflowing with ash at the end of the 72 hours. This has a number of implications for Atlantic Scottish archaeology. Firstly, the large volume of ash that would have been produced from the continuous burning of peat fires would create a large amount of material that could accumulate and be curated throughout the settlement. The spread of ash would therefore be an important contributor to what we would recognise as archaeological stratigraphy, trapping artefacts and ecofacts for recovery thousands of years later. Extensive ash spreads form an important group of samples within this study and almost every later prehistoric domestic site in the region has significant ash components within the recorded stratigraphy. These peat ash spreads are easily observed and sampled on the sites but ash from wood would be very difficult to spot apart from detailed soil micromorphology, due to its much smaller volume produced from similar burning periods.

From these observations, assuming the fuel was used for its economic efficiency, it seems likely that if available, well humified peat and perhaps peaty turf would be used as the main fuel source for heating and cooking as both types produce enough heat without using up too much fuel. It would appear to be uneconomic within the timber scarce Western Isles to use wood, except for perhaps starting fires or special activities, such as metalworking that require high temperatures quickly. Wood, straw and especially seaweed, produced a lot of acrid, unpleasant smoke and so would be unlikely to be used often within a domestic setting. However, curing animal and fish products may have utilised this smoke, especially if undertaken within an outbuilding or specially designed structure. Numerous discussions with local crofters and evidence gleaned from ethnographic data (cf. Martin, 1716; Fenton, 1978) has confirmed that well-humified peat was the dominant fuel source with peaty turf and fibrous upper peat used if the fire was needed to be kept going overnight. However, we need to turn to the archaeological evidence to understand fuel use in the first millennia BC and AD (see below).

5.7.2 Sourcing fuel type through mineral magnetism

Table 5.5 outlines the magnetic measurements and parameters for all the ash samples taken from the experimental hearths (for position of samples refer to Figure 5.13). Again, enhancement occurs when comparing the values of the sterile beach sand (S.1,47,88) with the ash samples from all of the various fuel sources. Three sets of column samples have been included to demonstrate this enhancement through two hearth profiles. Samples 91 and 92 were taken from FH13 (well humified peat) and Sample 102 was taken from FH14 (fibrous upper peat). All the columns show dramatic enhancement through the ash before returning to low values within the sand. However, the heat of the fire has slightly enhanced the magnetic character of the sand underlying both hearths (Samples 91/3, 92/2 and 102/4) and more marked enhancement also occurs in the underlying soil (Samples 92/3, 102/5). The underlying soil may have experienced more enhancement by the ignition of some organic material that was not possible in the sterile beach sand.

Figure 5.15 displays the biplot of χ by κ_{fd} for the bulk and sieved routine samples. Bulk samples refer to unsieved material whereas sieved samples refer to material less than 63μm. The sieved samples show a higher magnetic concentration than the bulk samples suggesting that sieving isolated the more magnetic ash component from the sand and other relatively larger clasts, which in general are only weakly magnetic. Complete discrimination can be seen between the four fuel types with the wood ash characterised by lower χ values (in a similar range as observed by McClean & Kean, 1993) than the other fuel types. Well humified peat ash samples have higher κ_{fd} values (average of 7.9%) than the fibrous upper peat (average of 6.0%), which in turn have higher values than the peat turf ash (average 4.7%). Discrimination is therefore beginning to emerge based on differences in total magnetic concentration (χ) and the concentration of superparamagnetic grains (κ_{fd}), part of the consistent pattern observed from the archaeological samples (Figures 5.10 & 5.11).

The statistical package BMDP, subprogram 7M (Dixon, 1985) was then used to carry out multivariate discriminant analysis on the magnetic parameters to find linear combinations of the data that show the greatest separation and least dispersion between the different fuel types. The two resulting discriminant analysis variables were used to produce the biplot in Figure 5.16. The main contributors to discriminant analysis variable 1 are SARM, SIRM and $ARM_{demag40mT}/SARM$ (aspects of domain state) and to variable 2, χ and $SARM/\chi$ (magnetic concentration). The biplot shows good discrimination between the well-humified peat and wood, with some overlap between the fibrous-upper peat and peat turf. Measurement of archaeological samples and subsequent calculation of the discriminant analysis variables allow the fuel source of the archaeological ash to be assessed, through comparison to the experimental data.

A second method of distinguishing fuel types using their magnetic signatures was developed from monitoring the variation of magnetic susceptibility with increasing temperature up to 700°C. The fibrous-upper peat and peat turf show characteristic drops in susceptibility at ~600°C, whereas the well-humified peat and wood display characteristic drops at ~330°C and/or ~550°C (see Figure 5.17). It is uncertain at present whether the observed differences relate to differences in mineralogy or domain state. The susceptibility curves could suggest mineralogy, possibly maghaemite, titanomagnetite or modified magnetite. However, subsequent low temperature magnetic measurements carried out on the modern ash residues using a $MPMS_2$ SQUID magnetometer suggests the differences relate to domain state. For example, the samples displaying drops in susceptibility at low temperatures have a high superparamagnetic component, whereas the samples displaying drops in susceptibility at high temperatures contain a higher proportion of stable single-domain grains (Peters *et al.*, forth. b). Despite the uncertainty in magnetic interpretation, the observed differences are consistent for the different fuel types and thus measurements of archaeological ash samples can be directly compared to the results from the modern ash samples to assess fuel type (Peters *et al.*, 2001).

The thermal history of the samples can also be investigated by comparing the heating and cooling susceptibility curves. Samples previously heated above 700°C should display no increase in susceptibility after heating/cooling, in particular at 40°C. The susceptibility curves from the experimentation (Figure 5.17) show that after heating and cooling the susceptibilities are either lower or similar to the pre-heating values, indicating that temperatures above 700°C were reached during the production of the ash. This clearly has implications for the preservation of plant macrofossils, discussed with reference to the archaeological samples below.

5.7.3 Archaeobotanical results

Ten bulk samples were taken and processed for archaeobotanical remains. Seven of these were taken from fire hearths of each of the main fuel sources, well-humified peat from FH13, peaty turf from FH14 & 17 and a mix of wood, fibrous upper peat, seaweed and straw from FH18. It was impossible to take a bulk sample of the wood ash as so little was produced and this was needed for the mineral magnetic analysis. Three samples were also taken in the summer of 2000 from the three dumps. Dump 1 consisted of well-humified peat, Dump 2 fibrous upper peat and Dump 3 a mix between peat turf and wood. The dumps were sectioned for soil micromorphology, the bulk samples representing the excavated half of the ash. Table 5.6 presents the results. The first key observation is that all human behavioural episodes involving input of plant material into the fire have left some form of remains relating to the activity. Every sample contained variable concentrations of the lichen (*Ramalina* sp.) and most samples had pine (*Pinus* sp.) wood, both of which were used as kindling to start the fire. Each fuel type had a specific suite of plant material of variable concentrations within it.

Turning first to the charcoal, unsurprisingly the most common type was pine timber, though pine roundwood was also recovered from four of the samples. In most cases this derived from the wood chippings used as kindling but in the case of S.128 from the mixed FH18 the fragments recovered are likely to represent the remains from burning timber logs. Figure 5.18 shows the ring profiles of the pine fragments from all the hearths, estimated from the rings counted in the transverse section of the charcoal fragments. Most timber fragments have small numbers of rings reflecting the small fragments of wood chippings from the 15-20 year old trees. However, the fragments from the timber logs in FH18 were also very small, demonstrating the near total combustion of the wood within the fires. Birch (*Betula* sp.) timber and roundwood fragments were also discovered in Dumps 1 and 3 as well as a single fragment of Ling heather roundwood (*Calluna vulgaris* L.). Again, the ring profiles of the assemblage are small (Figure 5.19). Most of the fragments came from the well-humified peat dump and as fuel input into the fire hearths was carefully controlled, it seems likely that the birch and heather was introduced from the peat. Clearly, this has important implications for the charcoal recovered from the archaeological sites as some of the fragments, especially birch, could have been introduced with the fuel source rather than from any direct use by the people around the hearth. Indeed, this is further evidence for the dangers of using charcoal as a dating medium in Atlantic Scotland as the birch will be approximately the same age as the peat. Further interpretative value of the presence of the birch fragments and the age profiles will become apparent in the following chapters.

Clear differences have emerged from the different fuel types (Table 5.6). The first difference involves the appearance and character of the burnt amorphous peat fragments between the well humified peat (whp) and the fibrous upper peat (fup) and peaty turf (pt). Whp produces an amorphous peat with no obvious structure whereas the other two types produce peat with obvious structural elements, such as specific layers of poorly humified fibrous material. These differences would be easily spotted from the burnt peat fragments in the archaeological record. The second difference involves the comparison of macrofossil concentration (QC/litre) between each of the types. Whp has very low concentrations (1.00 from FH13 and 0.64 from Dump 1) whereas fup and pt have much higher concentrations, ranging from 3.33 to 220 QC/litre. The few macrofossils recovered from the whp samples include indeterminate rhizomes, small culm bases and single seeds of Ling and sedge (*Carex* sp.). However, the fup and pt contain far greater numbers of culm nodes/bases and rhizomes, most of which can be separated from cereal straw parts on the basis of their size. Figure 5.20 shows the size range of these culm parts and rhizomes for the samples. Most of the remains are less than 2mm in diameter with the culm bases greater than 2mm in Samples 128 and 156 stemming from the straw burnt within the mixed hearth. Both fup and pt also have greater number of seeds from acid loving plants present on the heath from where the shallow peat and turf was cut. The carbonised seeds from these plants include heather, sedges, oraches (*Atriplex* sp.), Heath grass (*Danthonia decumbens* L.), undifferentiated grass (Poaceae), dock (*Rumex* sp.), Blinks (*Montia fontana* L.) and even a couple of seeds from the Bilberry family (*Vaccinium* sp.). Fruits from the Bilberry family could have provided gathered food in the past so the possibility of fuel contamination must be considered when interpreting archaeological seeds from this family. Past experimentation (McClaughlin, 1980; Bottema, 1984; Dickson, 1998) has proposed that burning turf would introduce large numbers of seeds from the turf living population but this experimentation has shown that the fup seems to contain slightly greater concentrations of seeds than the pt, though both types have significantly more seeds than whp. This can be explained by seasonality, as the pt and fup used in this experimentation was cut during the spring. Clearly, seeds would be produced in the turf during summer and early autumn so any seeds remaining in the spring would have been produced the previous year. Hence, large numbers of seeds were not present in the turf as most would have been dispersed or rotted. Also, the greater number of seeds in the fup can be explained by the preservation of seeds within the layers below the immediate turf line.

In summary, the different fuel types produced different suites of carbonised material in terms of concentration and composition. Also, for every type of plant material used in the firing of the hearth, including the lichen and wood shavings to start the fire in the peat burning, some aspect of that material, no matter how small, was preserved. We now turn to the application of the mineral magnetic results from archaeological material, as an independent proxy to identify the burning of these different fuels.

5.8 Archaeological application

5.8.1 Sample selection and processing for fuel sourcing

Samples from archaeological hearths and ash spreads were analysed using the detailed mineral magnetic work described above. All of the sites were analysed, apart from Gob Eirer as this site had displayed obvious signs of pedogenic post-deposition. Only hearth material and ash spreads were chosen as they have a low 'taphonomic heterogeneity' and so are more likely to represent a single burning episode. Other context types, such as floor levels and middens, are likely to contain ash from more than one burning episode and may contain other magnetic material of unknown origin, possibly of a bacterial magnetosome component (Peters *et al.*, 2000; 2001). Biogenic precipitation of magnetite by magnetotactic bacteria is possible within contexts with more organic content (Maher & Thompson, 1999). Figures 5.21 and 5.22 plot the ratios of SARM/SIRM and SARM/χ for hearths and floor levels and middens from Guinnerso and Galson. These parameters were found to indicate a bacterial magnetosome component within sediments by Barlow (1998). In both figures it can be seen that a bacterial magnetosome component may contribute to the overall magnetic signature from some of the floor levels and middens from the two sites, highlighting their unsuitability for identifying fuel sources.

All of the archaeological samples were sieved to 63 μm, to separate larger non-ash clasts and isolate the ash component. Figure 5.23 shows the χ values from the same set of sieves used in Section 5.6.4 from two sub-samples (S.311A & B) of material from within the rectangular hearth at Guinnerso. Again, this shows that the material below 63 μm had the highest magnetic concentration, reflecting the high proportion of ash.

5.8.2 Fuel sourcing from the archaeological sites

Figure 5.24 displays the discriminant biplots of the room temperature measurements for the hearth and ash spread samples from the archaeological sites. The samples are displayed as one assemblage for most of the sites, as the measurements were taken from the same general period (i.e. Mid Iron Age, Late Iron Age). Differentiation is only made between the Late Iron Age and Norse samples from Galson. More detailed discussion on the implications for the sites are presented within the individual site reports (cf. Church & Peters, 2000).

In general, most of the samples from the sites are grouping around the well-humified envelope within the biplot. This consistent pattern is confirmed by the high temperature susceptibility measurements, with representative samples displayed in Figure 5.25. For example, the three measurements from Bostadh, Galson and Guinnerso are consistent with the experimental profiles from well-humified peat (see Figure 5.17), with the susceptibility approaching zero by ~550-560°C. Conversely, the susceptibility approaches zero at ~600-610°C for a single sample from Dun Bharabhat, one of the few that recorded this profile from the sites in Lewis (Church & Peters, 2000). This sample also trends towards the peaty turf envelope in the room temperature biplot, representing a probable mix of well-humified and peaty turf confirmed by the character of the burnt peaty turf fragments from the bulk sample (Church, 2000). Overall, little change is observed over time, though slight variation can be seen from site to site in terms of their position within the biplot. For example, some samples from the three sites on the Bhaltos Peninsula (Dun Bharabhat, Cnip and Loch na Beirgh) plot to the right of the well-humified envelope (see below). Soil micromorphological analysis of key sections at An Dunan (both blocks), Galson (both blocks) and Guinnerso (**GUN-IA**) confirmed the dominance of well-humified peat ash in the hearth deposits and occupation material (Tams, pers. comm.).

However the one exception to this pattern is the samples analysed from the ash spreads in the body of Calanais kerb cairn. The biplot points to the fuel consisting of peaty turf. This was confirmed by soil micromorphological analysis of the ash spreads in the cairn (Carter, 2001), which suggested turf from a shallow peaty soil (similar to fibrous upper peat). The implications of this variability are discussed in terms of archaeobotanical taphonomy and fuel procurement strategies in Sections 5.8.3 and 7.4 respectively.

It is proposed that the uniformity and variation in the magnetic signatures of the ash rich samples are generally a reflection of the fuel source that produced the ash. However, there are a number of possible other effects that could create the variation observed. Firstly, the variation may relate to other fuel sources not part of the experimentation to this point. These include seaweed, dung, straw/hay, other types of organic turf and other types of wood, though McClean and Kean (1993) have shown that little magnetic variation occurs through the burning of different wood types. It would seem unlikely that straw/hay and seaweed would be burnt as a primary fuel as large amounts would be needed and the main product would be acrid smoke and little heat. Dung and other types of organic turf may have been used however and further experimentation planned in the future will burn these types. However, it is clear from the Calanais kerb cairn biplot that turf can be identified by this method.

Secondly, the underlying solid and drift geology from where the peat or turf was cut could introduce magnetic particles into the fuel, specific to that area. Hints that the geology may be a factor in magnetic variation stem from the consistent plot to the right of the well-humified envelope in the room temperature biplots of some samples from the three sites from the Bhaltos Peninsula in Lewis. Also, the sequence of samples taken from the Late Iron Age ash pit from Galson (MS3) displayed two similar, but slightly different, high temperature susceptibilities (Figure 5.26). The room temperature biplots from this ash pit are also consistent with the well-humified peat identification and the slight variation in high temperature susceptibilities could be interpreted in the light of subtly different mineralogies stemming from different sources of peat with different underlying drift geology. However, a number of specific magnetic susceptibility profiles through 'natural' peat and turf sections in Lewis have demonstrated only a very slight magnetic enhancement through the 'C' horizon, subsoil and underlying drift geology (cf. Table 5.2). Also, much of the Western Isles is underlain by Lewisian

Gneisses (Gribble, 1994) that are relatively inert magnetically. Superficially, this would suggest that the underlying geology is not an important factor but more research would be needed to investigate the effect of heat on the different mineral particles derived from the subsoil.

Thirdly, the pre-burning and post-depositional history of the fuel and its ash could affect its magnetic properties. For example, ethnographic evidence of Shetland's recent past (Fenton, 1978) suggests turf was commonly used as a flooring material in a byre or building, as well as a roofing material, before burning and there is anecdotal evidence of the charring and quenching of fibrous upper peat before its use in iron working, to improve its properties as a fuel (Dewar, 2000). Post-depositional processes and pedogenesis of archaeological deposits could also alter the magnetic properties of the samples. For example, floor levels and middens from Galson and Guinnerso displayed evidence of a possible bacterial magnetosome component in the samples (see above). More obvious pedogenic processes are easily identified on site, for example, the podzolization and iron-pan formation observed at Gob Eirer.

Fourthly, the input of magnetic material from sources other than the fuel is another possible factor in the variation. Processes such as metalworking, introduce highly magnetic material into the surrounding contexts and associated dumps (Sim, 1998). The choice of hearth material and ash spreads reduced the potential for such input, compared to floor levels and middens, and the use of sieved material less than 63μm will have removed many of these other magnetic particles, such as slag spheres and hammerscale from the metalworking process (Englike, 1991).

The final factor in the variation is mixing of the fuel sources themselves. To this point, the analysis is underpinned with the assumption that the ash results from the burning of a predominant fuel type in a single burning episode, supported by ethnographic observations from the recent past (Martin, 1716; Fenton, 1978). However, this was not necessarily the case in prehistory. Bands of well-humified peat and some peaty turf ash were located through soil micromorphology in the floor level immediately abutting the central hearth in Structure L at Bostadh (Tams, pers. comm.). Though distinct in thin section these bands would have been amalgamated when bulk sampled, in effect mixing the ash from the two different fuel sources. Unfortunately, the floor level was bulk sampled away from this area and so the mix of fuels could not be detected by mineral magnetic analysis. However, it is interesting to note that a few of the samples from Bostadh have large numbers of the smaller culm nodes and rhizomes that could have been derived from the burning of some peaty turf mixed with greater volumes of well-humified peat. The greater volume of well-humified peat ash with higher magnetic values would then mask the signal of the peaty turf but the macrofossils from the turf would still be preserved. Therefore, a series of low temperature remanences have been measured using a $MPMS_2$ squid magnetometer for the experimental samples. A quantitative unmixing algorithm was successfully developed to quantify fuel ash mixing for the few archaeological samples measured so far (Peters *et al.*, forth.b).

Despite these other factors in magnetic variability, it is likely that they would only slightly alter the magnetic character of the archaeological sample and it is felt that the dramatic enhancement from the burning of all the fuel types will over-ride these other factors.

5.8.3 Archaeobotanical implications of experimentation and generic taphonomic model

It has been demonstrated by the experimentation and past research (McLaughlin, 1980; Dickson, 1994, 1998) that different fuel types produce varying numbers and proportions of plant parts and species. In summary, peaty turf usually produces relatively large quantities of small culm bases and rhizome fragments, fibrous burnt peat and some seeds of heather (Ericaceae undiff.), grasses (Poaceae undiff.) and the sedges (*Carex* spp.). However, well-humified peat produces relatively large quantities of fragments of a much more amorphous carbonised peat and very few residual plant macrofossils, usually consisting of rhizome fragments. Therefore, sites that have well-humified peat as their dominant fuel source will have little in the way of contamination, apart from amorphous burnt peat and specific types of rhizome that can be easily identified. Sites which have more mixed fuel sources, especially turf, will have much greater problems with contamination. Hence, it can be proposed that the archaeobotanical assemblages from most of the Lewis sites will generally have little contamination. Only, the ash spreads in the body of Calanais kerb cairn will have significant macrofossil contamination from the fuel source, reflected by the character of the site assemblage (see Section 6.3.2). However, some of the samples (see Appendix B) contain significant numbers of the smaller culm nodes and rhizomes that could have derived from peaty turf ash mixed with greater volumes of well-humified peat ash. Therefore, in these samples fuel contamination of the archaeobotanical assemblage must be considered (see further discussion in Section 7.4.2).

To return to the generic taphonomic model outlined above, much of the plant material from this study was likely to be carbonised on a domestic hearth or as part of some funerary burning episode. The spread of ash throughout the sites largely accounts for the formation of the carbonised plant macrofossil assemblages recovered. The research described has demonstrated the application of mineral magnetism as an independent proxy to assess the validity of this generic model. However, caution must be exercised in interpreting the taphonomic history of archaeobotanical assemblages in Atlantic Scotland from this model alone as specific sets of archaeological deposits have yielded large quantities of carbonised plant material not derived from the ash spread from hearths. For example, large quantities of barley ears and straw were discovered on the floor of a secondary phase in Broch 2 at the Howe in Orkney (Ballin-Smith, 1994) that resulted from a crop-processing accident (Dickson, 1994). Also, a number of conflagration deposits have yielded very well-preserved carbonised plant macrofossils that represent a different taphonomy from the majority of deposits excavated in the region. A good example of this is the conflagration samples taken from the end of the secondary occupation at Dun Bharabhat, described in detail in Section 6.3.5.

So what are the implications for archaeobotanical analysis in Atlantic Scotland that stem from this generic taphonomic model? The first key implication is the potential misuse of those models previously used to interpret archaeobotanical assemblages in the rest of Britain (cf. Hillman, 1981; Jones, 1984; Jones, 1985; van der Veen 1991, 1992). The basic taphonomic underpinning of these models is that crop-processing debris forms the bulk of plant material carbonised on domestic hearths and subsequently recovered from archaeological sites. This may well be true of those areas referred to as 'lowland Britain' by van der Veen (1992), but seems inappropriate for the plant material from a variety of habitats carbonised in the hearths of Atlantic Scottish archaeology. Crop debris still forms a significant part of archaeobotanical assemblages in the region. However, the unquantifiable number of taphonomic pathways for the plants into the hearths and the subsequent spread of ash across the site negates 1) the classification of all wild species as weeds of an arable crop and 2) the interpretation of most plant material stemming from crop-processing accidents.

The second key implication is the preservation system for carbonised plant macrofossils within the ash of a typical domestic hearth. Approximate thermal histories of the peat ash were estimated with most of the archaeological ash heated to over 700 °C. This would totally destroy or severely degrade most plant material (Wilson, 1984; Boardman & Jones, 1990) and this phenomenon is reflected by the generally very poor preservation that characterises most archaeobotanical assemblages recovered from Atlantic Scotland. For example, Figure 5.27 (based on the data in Table 5.7) presents the preservation profile of cereal caryopses (n=24080) recovered from the 212 samples that contained grain following standardisation. The preservation of the grain was based on indices proposed by Hubbard & al Azm (1990), with class P1 representing perfectly preserved grain to class P6 representing severely degraded grain precluding even genus identification. Generally over 50% of the grain from most of the assemblages lay within the two worst preservation classes, indicating severe degradation of the grain during the carbonisation process. Less robust classes of material including chaff and wild seeds would be easily destroyed within this sort of carbonisation. Conversely, the grain from a barley thatch within a conflagration within the secondary structure in Dun Bharabhat (C.169) recorded over 65% of the grain within the two best preservation classes (Church, 2000). This indicates near perfect preservation, stemming from the slow carbonisation of the plant material in a relatively low temperature, reducing atmosphere within the collapsed structure.

Figure 5.28 presents the same cereal grain population (n=24080) for each of the generic context types (n=212) included in the analysis following standardisation. Again, it can be seen that the single sample from the conflagration in Dun Bharabhat is much better preserved than all the other context types that make up the vast majority of the samples analysed. Indeed, the similar preservation profiles for each of the context types provides further evidence for a similarity in carbonisation process, which probably occurred within the domestic hearth. The grains are slightly better preserved within floor levels that may point to limited input of material carbonised from other taphonomic pathways, such as crop-processing accidents. The poor conditions for macrofossil preservation also have implications for the level of identification possible. For example, Table 5.7 outlines the preservation profiles for the various cereal classes. Little identification is possible for the 'Cereal indeterminate', reflected by 98% of the grains being in the worst preservation class. Conversely, the profiles of the hulled symmetric and asymmetric barley grains are weighted in favour of the better preserved classes. There also seems to be a slight difference in the preservation behaviour of the cereal genera recovered (Figure 5.29). Oat (*Avena* sp.) and wheat (*Triticum* sp.) seem to be slightly better preserved than the amalgamated profile from the various barley classes (*Hordeum* sp.). This is likely to be a factor of the shape of the grains in the case of the oat and a subconscious inclination by the author to identify the relatively rare wheat using only better preserved grain.

In summary, the effects on the preservation of the archaeobotanical assemblages from the differing taphonomic histories are clear, with most archaeobotanical assemblages in Atlantic Scotland stemming from carbonisation within domestic hearths and therefore containing significant proportions of degraded cereal grain and other hardy plant parts, such as culm bases and rhizomes.

5.9 Conclusion

Returning to the original research problem of the admixture of plants and their associated habitats within a typical sample, it has been possible to propose and demonstrate a generic taphonomic model of the carbonisation on the hearth and the spread of ash and carbonised plant macrofossils through the site. Also, different fuel types produce different concentrations and types of plant macrofossils and it is possible to spot this sort of fuel contamination to the archaeobotanical assemblage through the independent proxy of mineral magnetism. The large preservation bias of the carbonisation process when burning peat, has also been highlighted.

However, the main problem is that all these insights come only from or after the point of carbonisation within the hearth. To return to the initial research problem, the admixture of plants is probably related to material that becomes incorporated into the hearth *prior to carbonisation* from an unknown number of uses of plants by humans. The experimentation at Calanais Farm showed that for every type of plant material used in the firing of the hearth, including the lichen and wood shavings to start the fire in the peat burning, some aspect of that material, no matter how small, was preserved. Hence, it would be very easy for the admixture to be formed through the day to day life around a central hearth in the dwelling of an extended family group, which was only cleaned out every two or three days if not longer.

So it seems that the basic research problem is not resolvable for most of the standard context types in Atlantic Scotland, for example the ash spreads, floors and middens, that constitute the major component of the archaeobotanical assemblages preserved by carbonisation. It is therefore important that the level of interpretation placed on this material is matched by the resolution of interpretation possible from such remains, bearing in mind the taphonomic complexity of the formation of the assemblage. For example, it is possible to identify different crop plants available and range of possible gathered foodstuffs during archaeological phases but interpretation of more detailed crop-processing procedures and weed ecologies is fraught with difficulty if based largely on material from ash spreads, floors and middens. This sort of detailed interpretation is only possible from deposits stemming from the survival of accidental fires, such as the crop-processing accident at Howe and conflagrations. Clearly, these sorts of deposits are very important for Atlantic Scottish archaeobotany as they circumvent the basic research problem of the admixtures of plant habitats from the mixing in the hearth prior to carbonisation.

Therefore research problems must be approached within the resolution of interpretation possible. It was hoped in the early stages of this research that the archaeobotanical assemblages could have been analysed using detailed statistical work to understand sophisticated aspects of the prehistoric plant economy, such as crop husbandry practices (cf. G Jones, 1991; van der Veen, 1992). However, the appreciation of the taphonomic complexity and the ultimately unresolvable question of the number of human behavioural episodes of discard into the hearths means the taphonomic assumptions underpinning these previous approaches are untenable in the study area. However, the generic taphonomic model is compatible with the amalgamation of the samples into general assemblages from each block and it is the results from these blocks that forms the backbone of the results discussed in the next chapters.

Chapter 6: Archaeobotany of West Lewis I: general results and the social dimension of plants

6.1 Introduction

This chapter presents the summary dating and the relative position of each of the site blocks within the first millennia BC and AD. The archaeobotanical results from each of the site blocks are then presented in approximate chronological order before addressing one of the interpretative research themes outlined in the introduction, the social dimension of plants. The first part of this research theme involves reconstructing aspects of the social landscape. This is attempted through the comparison of various concentrations and proportions of plant material at different sites of the Mid Iron Age, to assess any major differences that could be interpreted in the light of site function. The importance of plants in the belief systems is then investigated through analysis of a series of samples and sets of deposits that relate to funerary activity and other forms of structured deposition.

6.2 Summary dating

Table 6.1 presents the general dating of all the site blocks throughout the first millennia BC and AD. The ash layers from Calanais kerb cairn are not shown on this table as they date to the early to mid second millennium BC. Broad dating for the key archaeobotanical assemblages from elsewhere in the Western Isles is also shown. The chronological coverage is variable with only Gob Eirer (**GE**) and the early phase at Dun Bharabhat (**DB-P**) within the Early Iron Age compared to the greater number of blocks covering the rest of the Iron Age. The chronological span of each block takes into account the possible range of the radiocarbon dates at 95% confidence levels or maximum chronological range that a certain structural form or artefact could fall within. This means that most of the blocks cover a number of centuries resulting in a chronological resolution that is relatively coarse. This is especially true when comparing blocks from different sites without the stratigraphic relationships inherent within a single site's relative chronology. Therefore, the chronological narrative and inter-block comparison of contemporary sites forming the basis of many aspects of the four interpretative research themes is based on the grouping of the site blocks into the general periods outlined in Table 6.2.

6.3 General descriptions of each site block

6.3.1 General

Each section outlines the following:

- the taphonomy of the charred material within the block assemblage. In general the basic taphonomic model suggested in Chapter 5 will account for most of the charred material but some assemblages were formed by different mechanisms and these are highlighted when appropriate.

- the basic composition of the block assemblage through reference to the comparable tables of means of 1) Quantifiable Components/litre 2) caryopsis/litre 3) charcoal fragments and weight/litre (see Table 6.3). The means for each block were calculated by averaging the sample values for each of the parameters.
- the common plant macrofossils of the block assemblage through reference to the comparable tables of the total plant macrofossils for each block. This total represents the sum of the identifications made from all the samples in the site block (see Appendix B for sample identifications) and is displayed by three statistical parameters. The first parameter (Table 6.4) presents the total of the basic counts for each species. The second parameter (Table 6.5) presents each of the species as a percentage of the total of one of the three plant classes; grain, chaff and wild components. The percentage of the remains within each class of the total block assemblage is also shown. The third parameter (Table 6.6) presents the ubiquity scores for each species in each block. The score is expressed as a percentage of the total sample population in which the specific macrofossil type was recovered, following the methodology of Popper (1988). Flax seeds, though not cereals, have been included in the cereal grain class as they are presumably cultivated plants in their own right.
- the charcoal genera of the block assemblage through reference to the comparable tables of the total charcoal for each block. Again, this total represents the sum of the identifications made from all the samples in the site block (see Appendix B for sample identifications) and is displayed in the same three statistical parameters as the macrofossils; the total and percentage of the basic fragment counts (Tables 6.7 and 6.8), the total and percentage of the total weight (Tables 6.9 and 6.10) and the ubiquity score for each genera in each block (Table 6.11). The percentages of the assemblage totals for both fragment counts (Table 6.8) and the weight (6.10) were remarkably similar and so the fragment percentage is routinely quoted in the text unless specified otherwise. The charcoal was grouped by deciduous roundwood, deciduous timber, coniferous roundwood, coniferous timber and indeterminate identifications.
- the special deposits and samples identified subjectively by the author within the site blocks that contain assemblages of particular importance.

6.3.2 Calanais Kerb Cairn (**CC-3**)

Taphonomy

Following standardisation, 12 macrofossil and 14 charcoal samples remained from the ash spreads within the body of the cairn. Mineral magnetic analysis (see Sections 5.4 & 5.8.2) and soil micromorphology (Carter, 2001) suggested that the ash layers resulted from the dumping of the ash from peaty turves, which can be interpreted as structured deposition of ash from domestic hearths or funerary activity, such as pyres. The possibility of structured deposition was supported by the observation of layers of decomposed organic material interleaved with the ash. These were shown to be a mixed plant assemblage similar to the carbonised plant macrofossil assemblage (Milburn, 2001). The charcoal and carbonised plant macrofossils therefore represented a mix of small culm nodes, bases and rhizomes and seeds from the peaty turf (see Section 5.7) with other plant material incorporated into the burning, including material from both arable and rough grazing habitats.

Carbonised plant material

The macrofossil concentration for the block (mean QC/litre) was relatively high, a function of the taphonomic input of the plant material from the peaty turf fuel. Conversely, the charcoal concentration was generally low, in keeping with many of the other blocks. This could indicate only a small amount of wood incorporated into the fire and also may represent an ashing phenomenon similar to the almost total carbonisation of wood within the experimental hearths (see Section 5.7). The total assemblage (n=1952) was dominated by wild components (74%), with some grain (22%) and relatively little chaff (4%).

The most numerous charcoal fragments consisted of birch, hazel and willow timber with a little oak. The roundwood consisted of numerous fragments of hazel and willow with some birch. All of these genera are deciduous and appear in the contemporary pollen spectrum at the nearby site of Loch na Beinne Bige (Edwards *et al.*, 1994). It is likely that most of the fragments were incorporated into the fire deliberately as additional fuel rather than with the peaty turf.

Many of the carbonised plant macrofossils relate to the burning of the peaty turf, indicated by the high proportion of components from wild species present within the samples. These include large quantities of small culm bases, nodes and rhizome fragments (less than 2mm in diameter), fibrous burnt peat and seeds and other plant components of heather (*Erica/Calluna* spp.), sedges (*Carex* spp.) and grasses (Poaceae undiff.), notably Heath-grass (*Danthonia decumbens* L.). Other plants that could have been part of the peaty turf include Bilberry (*Vaccinium myrtillus* L.), *Cowberry (Vaccinium vitis-idaea* L.), Tormentil (*Potentilla erecta* L. Raeusch) and some of the species preferring damp ground such as the Marsh groundwort (*Stachys* cf. *palustris* L.).

There is also evidence of cultivated plants with wild species indicating the associated arable weed ecology or pastoral areas. The identifiable cereals were dominated by barley, with less than 1% wheat and oat. The latter two species were likely to be weeds of the barley crop, rather than crops in their own right. Approximately 44% of the identifiable cereals were hulled barley with just over 11% naked. No rachis internodes were recovered, so species identification was based on the ratio between symmetric:asymmetric grains (cf. Renfrew, 1973). From this (exactly 1:2; n=36), the hulled barley was likely to be six-row, with the two and six row species possible for the naked barley (1.2:1; n=11).

The most numerous seeds included those of Goosefoot/Orache (*Chenopodium/Atriplex* spp.), Common chickweed (*Stellaria media* L. Vill.), Knotgrass (*Polygonum aviculare* L.), Sheep's sorrel (*Rumex acetosella* L.), Curled dock (*Rumex crispus* L.), Cabbage/Mustard (*Brassica/Sinapis* spp.), Wild turnip (*Brassica rapa* L.), Ribwort plantain (*Plantago lanceolata* L.) and grasses (Poaceae undiff.). These species are ubiquitous weeds of cultivation and disturbed ground with the presence of Common chickweed hinting at nitrogen enriched soils (Sobey, 1981), from deliberate manuring or pastoral activity. The presence of Sheep's sorrel hints at damp ground. On the other hand, the preference of Wild turnip in modern Lewis is for the free-draining machair (Pankhurst & Mullin, 1994). Less frequent wild species included Creeping buttercup (*Ranunculus repens* L.), the Common (*Urtica dioica* L.) and Small nettle (*Urtica urens* L.), Spear-leaved orache (*Atriplex hastata* L.), Blinks (*Montia fontana* L.), Corn-spurrey (*Spergula arvensis* L.), Pale persicaria (*Persicaria lapathifolia* L. Gray), Redshank (*Persicaria maculosa* Gray), Common sorrel (*Rumex acetosa* L.), Wild radish (*Raphanus raphanistrum* L.), Common hemp-nettle (*Galeopsis tetrahit* L.), Corn marigold (*Chrysanthemum segetum* L.) and Annual meadow-grass (*Poa* cf. *annua* L.) Again, this represents a mix of habitats from damp, acidic conditions (Blinks) to alkali, sandy areas (Corn-spurrey). A number of species that could have been gathered for human consumption, such as the Bilberry and Cowberry, were also recovered.

This mixed seed ecology can be interpreted in a number of ways. Firstly, the damp, acidic indicators may have been introduced into the assemblage through the peaty turf fuel. Also, the mix could represent different areas of cultivation for the hulled and naked barley. Alternatively, it may represent the incorporation of grassland material from areas used for pastoral activity. Milburn (2001) noted that the pollen spectra from one of the decomposed plant levels interleaved with the ash spreads contained evidence of moorland and damp grassland species as well as arable areas. These included heather, grasses (Poaceae undiff.), docks (*Rumex* spp.), Ribwort plantain and a small proportion of cereal pollen that were present in significant quantities in the carbonised plant macrofossil assemblage. This material from damp grassland could have been used for fodder and was incorporated into both the fire and the body of the cairn. Again, this may represent accidental incorporation but more likely it is an example of structured deposition, linking the ceremony to the wider physical and economic landscape (see Section 6.5 below).

6.3.3 Gob Eirer (**GE**)

Taphonomy

Following standardisation 18 macrofossil and 30 charcoal samples remained from the various generic occupation layers. The post-deposition alteration of the soil properties across the site meant that the mineral magnetic measurements were almost uniformly low. Therefore the taphonomic history of the assemblage was hard to demonstrate but it seems likely that the charred material was carbonised on domestic hearths due to the association of burnt peat with most of the samples with significant numbers of plant macrofossils. The pedogenic history of the site also meant that many of the macrofossils and charcoal acted as filters for the iron pan formation across the site and this severely degraded and destroyed many of the more fragile macrofossils. This contributed to the grain and culm base / rhizome rich nature of the assemblage, the more hardy parts of plants judging by the carbonisation experiments undertaken by Boardman & Jones (1990).

Carbonised plant material

The macrofossil concentration for the block (mean QC/litre) was low, as were the average number and weight of the charcoal fragments (charcoal fragment & weight/litre). The low concentrations in part reflect the post-deposition pedogenic destruction of the charred material. The total assemblage (n=584) was dominated by grain (65%), with some chaff (9%) and rather more wild components (26%).

A wide range of charcoal genera were recovered, with 39% of the fragments deciduous roundwood, 16% deciduous timber, less than 1% coniferous roundwood, 15% coniferous timber and 29% indeterminate. Ling heather and birch were the most numerous of the deciduous roundwood, with some hazel and Pomoideae undifferentiated and a few fragments of alder. The deciduous timber was largely birch, with some alder, oak and a little ash. The ash is the only species that is unlikely to have grown in the Western Isles (Pankhurst & Mullin, 1994) as it prefers the base-rich deep soils of the mainland (Stace, 1991). Its presence, along with the fragments of oak, raises the intriguing question of importing timber or perhaps opportunistic gathering of driftwood (see Section 7.3). The coniferous timber consists largely of pine with some spruce and a little larch. Much of this would have been collected as driftwood as the spruce and larch were not native to the British Isles at this time. The pine could also have been driftwood as only a very small amount of pine roundwood was recovered from the site indicating its local presence but no more.

The identifiable cereals were all barley, with approximately 58% of the barley hulled and 3% naked. All five rachis internodes recovered were of the six-row species, though the ratio between the symmetric:asymmetric hulled barley grain was 1:1.3 (n=30), suggesting that the two-row species may also have been present. The only other chaff present was large culm nodes and bases.

The wild components were dominated by smaller culm nodes and bases and rhizomes, a function of their durability and the probable burning of some form of peat. The very low concentration of wild seeds included Cabbage/Mustard, sedge (*Carex* spp.), Ribwort plantain, Corn Marigold, grasses (Poaceae undiff.), Knotgrass and Sheep's sorrel. These species cover a range of possible habitats including arable, disturbed ground, rough pasture and moorland. Two fragments of hazel nutshell and a single seed of Rowan (*Sorbus aucuparia* L.) point to the presence of local woodland and its exploitation in the form of nuts and berries becoming incorporated into the domestic fires.

6.3.4 Dun Bharabhat primary and main blocks (**DB-P; DB-M**)

Taphonomy

Following standardisation a single macrofossil and charcoal sample remained from the underlying block and one macrofossil and three charcoal samples remained from the Atlantic roundhouse block. All the samples were generic occupation contexts with significant magnetic enhancement (Section 5.4), indicating the carbonisation of the material probably occurred within a domestic hearth. Fuel sourcing by mineral magnetism (Section 5.8) showed much of the ash to be derived from well-humified peat with a single sample displaying a high-temperature curve similar to peaty turf (Church & Peters, 2000).

Carbonised plant material

The macrofossil concentration for both blocks (mean QC/litre) was relatively high, as was the average number and weight of the charcoal fragments (charcoal fragment & weight/litre) in the underlying block, though this is probably a function of the single sample in the block total skewing the average. The charcoal concentration of the Atlantic roundhouse block was much lower. The total macrofossil assemblage (n=63) of the underlying block was dominated by grain (81%), with a little chaff (5%) and wild components (14%). The total assemblage of the Atlantic roundhouse block (n=44) was totally dominated by wild components (98%), with only a single barley rachis internode making up the rest of the assemblage. However, as both macrofossil assemblages were represented by a single sample caution must be exercised for any inference made.

28 charcoal identifications were made from the earlier block of which Ling heather made up over 60%. Some birch roundwood and pine timber was also recovered. Only two fragments of charcoal were recovered from the Atlantic roundhouse sample and these consisted of Ling heather and pine timber. All species were available locally judging by the pollen sequence from the loch (Lomax & Edwards, 2000).

Identifiable cereal grains were only recovered from the underlying block and these were all barley, of both the naked (7%) and hulled (54%) variety. Both blocks contained a single rachis internode of six-row barley and there was a single large culm node and base in the underlying block.

Very few wild components were recovered from the underlying block. These included a few seeds of Wild turnip, heather, grasses (Poaceae undiff.), Chickweed and a single small culm node. Again a mix of habitats was represented. The assemblage from the Atlantic roundhouse was dominated by seeds of Wild turnip with a few seeds of Fat Hen (*Chenopodium album* L.), Knotgrass and Chickweed. All of these plants are common weed seeds of an arable crop within the machair (Pankhurst & Mullin, 1994) and the Wild turnip was a recurrent seed recovered from all of the sites on the Bhaltos peninsula (see Section 7.2 for further discussion). This sample may therefore represent the remains of a barley crop-processing residue added to the fire.

6.3.5 Dun Bharabhat secondary block (**DB-S**)

Taphonomy

The deposits from the secondary occupation consist of a series of generic occupation levels overlain by a conflagration deposit, containing burnt timbers and multiple ash layers, which have been interpreted as the remains of the roof destroyed by fire. Following standardisation, no macrofossil and only four charcoal samples remained from the generic occupation levels. Five hand-retrieved timber samples along with a single bulk sample of pure burnt material (C.169) were taken from the conflagration deposits. The sample from the generic occupation horizons all displayed significant magnetic enhancement (Section 5.4), indicating that the carbonisation of the material probably occurred within the observed domestic hearth. Fuel sourcing through detailed mineral magnetic analysis suggests that the main fuel source was well-humified peat (Section 5.8).

The conflagration horizon seemed to represent the undisturbed remnants of a roof fire. All the plant macrofossils in the conflagration level, from the cereal remains in the bulk sample (Context 169) to the burnt timber, were very well preserved (see Section 5.8.3). This allowed much more detailed identification for Context 169 than is usually possible for material derived from the occupation levels from Atlantic Scottish sites. This excellent preservation stemmed from the carbonisation process that occurred during the conflagration. The roof, if left to burn, would eventually have collapsed in. This would have provided excellent conditions for slow carbonisation of plant material at a relatively low heat, within a reducing atmosphere (G. Thomas, pers. comm). Experimental work by Boardman & Jones (1990) has shown that these conditions produce the best preservation, in terms of density, condition and the range of plant parts, many of which (the chaff, culms and seeds) would be destroyed in higher temperatures.

The formation processes of the carbonised assemblage in the conflagration level also allowed the plant remains to be related to specific functions. For example, the burnt timbers were used as structural components within the roof, whilst the cereal rich Context 169 has been interpreted as a barley thatch, though it may be possible that it represents bedding, flooring or stored straw within the loft or roof of the structure. This degree of certainty when dealing with macrofossil taphonomy is very rare within Atlantic Scotland, due to the nature of the taphonomic model presented in Chapter 5. This removes the usual problems of taphonomic interpretation, so more confident and detailed analysis of issues such as timber procurement and arable agriculture are possible from such remains.

Carbonised plant material

The three samples from the generic occupation horizons contained only seven charcoal fragments, four of which were Ling heather with single pieces of hazel, spruce and pine timber. The timber in the conflagration comprised entirely pine and spruce, with small amounts of birch and Ling heather roundwood. The timber was in excellent condition and so identification was possible for most fragments, including the ring counts for all the fragments. The deciduous birch and Ling heather roundwood had relatively low ring counts, with the highest counts being 16 and eight respectively. These fragments were presumably present within the roof, perhaps as furnishings such as heather rope or birch wattle. Both these taxa would have been available locally.

Figures 6.1 and 6.2 show the ring counts for all the pine and spruce. All the fragments were of timber with the highest ring counts for the spruce and the pine being 66 and 94 respectively. The high number of low ring counts reflects fragmentation following recovery of the charcoal, rather than the presence of roundwood or selection of smaller timber. Further morphological characteristics provided information on the nature and origin of the timber. Several of the spruce fragments contained bore holes, which past researchers have taken as evidence for the use of driftwood (Dickson, 1992; Malmros, 1994; Taylor, 1999). This seems to be the likely source for the spruce, as the taxa was not present in the British Isles during the Iron Age. The timber could have drifted from North America or even Siberia, having first been transported by ice flow through the Arctic (Dickson, 1992). The pine did not exhibit any sign of boreholes and bark fragments were recovered from Context 169. Also, the ring patterns from the larger pine fragments were very narrow, which suggests the tree was growing in very stressed conditions. This evidence, coupled with the presence of Scots Pine (*Pinus sylvestris* L.) pollen in subzone BH2.IIIb (Lomax & Edwards, 2000), may indicate the use of locally derived timber. Therefore the procurement strategies for timber were both opportunistic, in terms of the driftwood, and also potentially managed in the case of the locally derived pine.

As stated above, Context 169 contained a high density of very well preserved carbonised cereal plant macrofossils. Much of the plant material was derived from cereal straw including nodes, bases and thousands of culm fragments. The assemblage was therefore interpreted as a possible fragment of thatch. The straw crop seems to be a mix of six-row hulled barley and two-row hulled barley. From the proportions of the rachis fragments, 73% of the assemblage was six-row with 27% two-row. Also, the ratio of the symmetric:asymmetric grain of 1:1.4 (n=318) within the deposit confirmed a mix of six-row and two-row barley, with the six-row species dominant. The identification of two-row barley is surprisingly rare within the Atlantic Scottish Iron Age. This is partly because of the relative rarity in survival of those features (sterile lateral spikelet and rachis internode) which are used to differentiate the species but may also suggest sophisticated management of the arable resource through selective cultivation of specific species and variants for different functions. For example, the presence of two-row barley in a thatch may be due to particular qualities the straw from this species exhibit (see Section 7.2 for further discussion).

The high number of culm bases of both cereals and smaller monocotyledons and weed associations with low lying plants, such as the violets (*Viola* sp.), suggests that the crop was harvested by uprooting. The straw would have been removed early in the crop-processing, in the threshing stage for example. This is confirmed by the ratio between the culm bases and the basal rachises (4.6:1), which shows that most of the ears were separated from the straw prior to its use as thatch. Hence, we can estimate approximately 80% efficiency for the separation of the ear from the straw during early crop-processing.

The presence of wild taxa within the straw presumably relates largely to weed contamination of the crop. Heather furnishings, such as rope or twine, can explain the limited presence of heathland taxa, such as the heathers. The remaining taxa are all common weeds of cultivation and dry grassland. The presence of Chickweed indicated relatively nitrogenous soil conditions, presumably enhanced through the addition of animal manure and seaweed to the soil. Several of the species, including Ray's knotgrass (*Polygonum* cf. *oxyspermum* M & B ex. Lb), Bulbous buttercup (*Ranunculus bulbosus* L.) and Wild turnip have strong associations with machair grassland (Pankhurst & Mullin, 1994). This evidence, coupled with a second series of pollen sequences from Loch na Beirgh (Lomax, 1997), pointed to the cultivation of the crop occurring largely within the machair grassland behind Traigh na Beirgh. The implications of the evidence from this deposit in the interpretation of samples from the other sites on the Bhaltos Peninsula (Loch na Beirgh and Cnip) is discussed in Section 7.2.

6.3.6 An Dunan underlying block (**AD-IA**)

Taphonomy

Following standardisation 10 macrofossil and 42 charcoal samples remained. Mineral magnetic analysis (Section 5.4) and soil micromorphology (Tams, forth.) suggested that much of the charred material stemmed from the spread of ash from the elaborate hearth in the centre of this funerary structure. Indeed, the very high magnetic susceptibilities measured from the hearth material and generic occupation levels suggested a significant component of the site's stratigraphy was ash derived. This was confirmed by the two soil micromorphological profiles through the hearth and occupation material. The fuel sourcing outlined in Section 5.8 indicates that well-humified peat was the main fuel. Much of the plant material incorporated into this large hearth burning at comparatively high temperatures would therefore have been completely ashed (cf. Boardman & Jones, 1990).

Carbonised plant material

The macrofossil concentration for the block (mean QC/litre) was relatively low, as were the average number and weight of the charcoal fragments (charcoal fragment & weight/litre). The low concentrations may in part reflect the intensity of burning produced on the large hearth. The total assemblage (n=255) was dominated by wild components (66%), with some grain (30%) and very little chaff (4%).

A relatively wide range of charcoal genera was recovered, with 53% of the fragments deciduous roundwood, 5% deciduous timber, 19% coniferous timber and 23% indeterminate. The largest proportion of the deciduous roundwood consisted of Ling heather that may have been incorporated into the elaborate hearth with the well-humified peat or as a fuel in its own right. Some birch, hazel and Pomoideae undifferentiated roundwood were also recovered along with a little alder, *Prunus* sp. and a single fragment of Purging buckthorn (see below). The small amount of deciduous timber included birch, hazel and oak, whilst the coniferous timber was a mix of pine and spruce. All of the deciduous species would have been available locally at the time, judging by the pollen spectrum produced from Loch Bharabhat (Lomax & Edwards, 2000) and Loch Ruadh Guinnerso (Flitcroft, 1997) a few kilometres from the site. The exotic conifers and perhaps some of the pine are likely to have been collected as driftwood.

The identifiable cereals were dominated by barley, with a single grain of oat and flax in two samples. The oat was likely to be a weed of the barley crop incorporated into the hearth but the flax is particularly interesting as it represents the earliest identification of flax within a well dated and sealed context in the Western Isles (see below). 88% of the identifiable cereals was hulled barley. No rachis internodes were preserved and the ratio of symmetric:asymmetric hulled barley grain was 1:1.3 (n=14), suggesting the presence of both two and six row barley. However, this ratio is based on only 14 grains so caution must be exercised from the inference. The only chaff present was a single large culm node and eight culm bases.

The wild components were dominated by the smaller culm nodes and bases and rhizomes, a function of their durability and the burning of well-humified peat. The low concentration of wild seeds included Cabbage/Mustard, sedge (*Carex* spp.), Ribwort plantain, grasses (Poaceae undiff.), Knotgrass, Curled dock, Corn spurrey, Chickweed and Sheep's sorrel. These species cover a range of possible habitats including machair, arable, disturbed ground, rough pasture and moorland. A few seeds of Crowberry and Bilberry were also recovered. These may represent the incorporation of berried plants into the funerary hearth as a deliberate act or as part of the fuel and other plant material used to cremate the bodies.

Special deposits

Two of the samples contained single fragments of particularly noteworthy plants. Sample 110, from within the central funerary hearth, contained a fragment of Purging buckthorn roundwood of approximately eight years growth. Mis-identification is unlikely as the transverse profile of this species is very distinctive and a positive second opinion was given by Dr. Mike Cressey. Fragments of cremated human bone were also recovered from the same context (Murphy, pers. comm.). Sample 47, an ash spread directly linked stratigraphically to the elaborate hearth, also contained a single flax seed and two radiocarbon samples of Mid Iron Age date (see Section 4.12). It seems likely that both represent some form of structured deposition of plants embodying special meaning because of their novelty and rarity. More consideration is given to these deposits in Section 6.5 below.

6.3.7 Guinnerso (**GUN-IA**)

Taphonomy

Following standardisation 12 macrofossil and 24 charcoal samples remained. Mineral magnetic analysis (Section 5.4) and soil micromorphology (Tams, forth.) suggested that much of the charred material stemmed from the spread of ash from the central hearth in the cellular structure. Fuel sourcing through detailed mineral magnetic analysis (Section 5.8) suggests that the main fuel source was well humified peat, with some indication of wood being burnt, presumably in the form of heather (Peters *et al.*, 2001).

Carbonised plant material

The macrofossil concentration for the block (mean QC/litre) was low, as were the average number and weight of the charcoal fragments (charcoal fragment & weight/litre). The total assemblage (n=698) was dominated by wild components (89%), with a little grain (8%) and very little chaff (3%).

A wide range of charcoal genera was recovered, with 43% of the fragments deciduous roundwood, 6% coniferous roundwood, 43% coniferous timber and 8% indeterminate. The deciduous roundwood was dominated by fragments of Ling heather and birch, which could have been incorporated into the hearth with the well-humified peat or burnt as fuel in their own right. A few fragments of alder, Pomoideae undifferentiated and willow roundwood were also recovered. The coniferous roundwood was split between pine and juniper, the latter species being possibly collected for its berries and the waste thrown on the fire or used as kindling. The conifer timber was dominated by larch with some fir and spruce, all of which would have been collected as driftwood. A small amount of possibly locally derived pine was also recovered. All of the deciduous species and the pine would have been available locally at the time, judging from the pollen spectrum taken from Loch Ruadh Guinnerso (Flitcroft, 1997).

The identifiable cereals were a mix between barley and oat, though the grain concentrations were very low compared to some of the domestic assemblages. The barley was exclusively hulled when further identification was possible and the ratio between symmetric:asymmetric barley grain was 1:1.5 (n=10), pointing to the possible presence of both two and six-row barley. However, only ten grains were used for this ratio so caution must be exercised in the interpretation for species differentiation. Much of the oat came from a single sample and represents one of the earliest small burnt caches of oat in the Western Isles. Whether the oat was cultivated in the surrounding blackland or represents a cache of wild oat will be assessed in Section 6.4. The only chaff present was 18 large culm bases.

The wild components were dominated by relatively large numbers of the smaller culm nodes, bases and rhizomes, a function of their durability and the burning of well-humified peat. The lower concentration of wild seeds included Cabbage/Mustard, Wild turnip, sedge (*Carex* spp.), Ribwort plantain, Heath grass, various sizes of grass (Poaceae undiff.), Knotgrass, Curled dock, Corn spurrey, Chickweed, Sheep's sorrel, Ling and other heathers. These species cover a range of possible habitats including arable, disturbed ground, rough pasture and moorland. However, most species probably came from moorland habitats that would fit in well with local exploitation of the various plant communities surrounding the site in the blacklands. A significant resource within such an area was the various berried plants and seeds of Bearberry (*Arctostaphylos uva-ursi* L. Sprengel), Bilberry, Cowberry, Crowberry (*Empetrum nigrum* L.) and Juniper (*Juniperis communis* L.) that became incorporated into the central hearth, presumably accidentally, during berry processing or with the fuel source or heather.

6.3.8 Cnip all blocks (**CN-W; CN-C; CN-R**)

Taphonomy

Following standardisation three macrofossil and nine charcoal samples remained from the Wheelhouse block, one macrofossil and 11 charcoal samples from the Cellular block and four macrofossil and six charcoal samples from the Rectilinear block. All the samples were generic occupation contexts with significant magnetic enhancement (Section 5.4), indicating the carbonisation of the material probably occurred within a domestic hearth. Several hearths were noted during the excavations of each of the blocks. Fuel sourcing through detailed mineral magnetic analysis suggests that the main fuel source was well-humified peat (Section 5.8).

Carbonised plant material

The macrofossil concentrations (mean QC/litre) were within the normal range of domestic blocks. Interestingly, the average number and weight of the charcoal fragments of all the blocks were relatively high (charcoal fragment & weight/litre). The total assemblage of the Wheelhouse (n=108) and Cellular (n=13) blocks was dominated by grain (92 and 85% respectively), with few wild components (2 and 7%) and small quantities of chaff (6 and 8%). Conversely, a large proportion of the total assemblage from the Rectilinear block (n=106) consisted of wild components (62%), with some grain (29%) and a little chaff (9%). However, only relatively small numbers of Quantifiable Components were identified from the three blocks so caution must be exercised with interpretation.

35 charcoal fragments were identified from the Wheelhouse block and these were dominated by pine roundwood, with a little willow timber. 90 fragments were recovered from the Cellular phase, of these a significant proportion were willow roundwood, with some birch roundwood, willow timber and pine roundwood. 67 fragments were identified from the Rectilinear block, dominated by oak timber, with

some willow roundwood and a little hazel roundwood. The assemblages are quite different in composition from the other domestic assemblages in the block data set. This, along with the relatively high charcoal concentrations, raises the intriguing possibility of a different wood and timber procurement strategy being practised by the inhabitants of the Cnip site, a concept explored in more detail in Section 7.3.

All the identifiable cereals were of hulled barley and the presence of the six-row species was indicated by the recovery of a single rachis internode in both the Wheelhouse and Rectilinear blocks. The ratio of symmetric:asymmetric grain of 1:2.3 (n=33) and 1:3.5 (n=9) in the Wheelhouse and Rectilinear blocks also confirmed the probable dominance of the six-row species. The only fragments of chaff included a single large culm node in the Rectilinear block and a few large culm bases in all three blocks.

Very few wild components were recovered from the earlier blocks with two small culm bases and a rhizome from the Wheelhouse block and a single indeterminate seed from the Cellular block. The other wild components covered a range of habitats with seeds from the Cabbage / Mustard families, Ling heather, sedge (*Carex* spp.), Heath grass, grasses (Poaceae undiff.), Knotgrass, Curled dock and violet. Four seeds of Slender St. Johns Wort (*Hypericum pulchrum* L.) were recovered from a floor level, a species embodied with supernatural and medicinal powers in the recent past (Bennett, 1994).

6.3.9 Loch na Beirgh roundhouse and cellular blocks (**LB-R; LB-C**)

Taphonomy

Following standardisation, a single macrofossil and charcoal sample remained from the Roundhouse block and 20 macrofossil and 23 charcoal samples remained from the Cellular block. All the samples were from generic occupation contexts with significant magnetic enhancement (Section 5.4), indicating the carbonisation of the material probably occurred within a domestic hearth. Fuel sourcing through detailed mineral magnetic analysis suggests that the main fuel source was well-humified peat (Section 5.8).

Carbonised plant material

The macrofossil concentration for the Roundhouse block (mean QC/litre) was quite low, though the average number and weight of the charcoal fragments was relatively high (charcoal fragment & weight/litre). The total assemblage (n=238) was dominated by wild components (62%), with some grain (26%) and a little chaff (12%). Again, the block assemblage was based on a single sample so only limited inference can be made from the basic composition of the assemblage. Conversely, 4459 identifications were made from the twenty standardised samples from the Cellular block, providing a more substantial and representative data set. The macrofossil concentration (mean QC/litre) was quite high, as were the average number and weight of the charcoal fragments (charcoal fragment & weight/litre). The total assemblage was dominated by grain (63%), with relatively smaller proportions of chaff (19%) and wild components (18%).

Only 20 identifications were made from the single sample in the Roundhouse block. A significant proportion consisted of Ling heather with a little birch roundwood and single fragments of hazel and Pomoideae undifferentiated roundwood and spruce timber. A much greater range of genera was recovered from the Cellular phase. Again, a significant proportion of the assemblage (45%) consisted of Ling heather. Further deciduous roundwood identifications included some birch and hazel and a little alder and Pomoideae undifferentiated. Some birch timber was also recovered, as well as a little alder, hazel, willow and Pomoideae undifferentiated. All of these genera were present in low amounts in the contemporary pollen diagrams at Loch na Beirgh (Lomax, 1997) and Loch Bharabhat (Lomax & Edwards, 2000). Some pine timber was also recovered, as well as proportionally small amounts of fir, larch, spruce and Douglas fir. The latter four plants were exotic to the Western Isles during the first millennia and so represent opportunistic gathering of driftwood. Again, the pine could either have been managed within a local copse or collected as driftwood (see Section 6.3.5 above). However, all of the coniferous timber fragments were too small to assess further structural and morphological characteristics that could have aided in the identification of a locally managed resource.

The identifiable cereals from the Roundhouse sample were dominated by hulled barley, with two seeds of flax and a single grain of oat. The oat was probably a weed of the barley crop. It is difficult to assess the status of the flax, though it may have been grown in its own right, representing one of the earliest examples of the crop in the Western Isles. Asymmetric grains of both varieties of barley were present and 13 rachis internodes of six-row barley were also recovered. Interestingly, a single rachis internode of two-row barley was also present. The possible mix of six and two row species was also indicated by the symmetric:asymmetric hulled grain ratio of 1:1.4 (n=12). The only other chaff fragments were two undifferentiated barley rachis internodes and a few large culm nodes and bases.

Almost 2800 grains were identified from the Cellular phase dominated by barley; of these 79% were hulled and less than 1% naked. Four grains of wheat and three of oat were recovered, presumably as weeds of the barley crop. Five seeds of flax were also present, a very small proportion of the total assemblage meaning the possibility of cultivation was difficult to assess. The chaff was dominated by six-row barley rachis internodes and large culm bases, with some large culm nodes and two-row barley rachis internodes. A couple of floret bases of cultivated oat, a single sterile lateral spikelet from two-row barley and a fragment of cereal awn were also recovered. Of the identifiable barley rachis internodes, 95% were from the six-row species and 5% from two-row. This predominance of six-row with some two-row barley is supported by the ratio of asymmetric:symmetric hulled grains of 1.7:1 (n=966).

147 wild components were recovered from the Roundhouse block. Significant numbers of seeds and

other plant parts of Wild turnip, heather, sedge (*Carex* spp.) and Chickweed were identified with some Ribwort plantain, grasses (Poaceae undiff.), Knotgrass, Curled dock and small culm parts and rhizomes. Single seeds of Bearberry, Juniper, Common fumitory (*Fumaria officanalis* L.), Common hemp nettle, Blinks, Tormentl, Common sorrel, Clover (*Trifolium repens* L.) and violet were also recovered. As usual, the wild components represented a wide range of habitats from moorland to arable weed contaminants. The Bearberry and Juniper could represent deliberate gathering of moorland berries or have been incorporated as part of the well-humified peat fuel or heather burnt on the domestic hearths as kindling.

A much wider range of plants from a variety of habitats were recovered from the Cellular block, with 823 identifications made. Just under half of the wild components consisted of small culm parts and rhizomes, which could have been incorporated into the hearths as part of the well-humified peat or as grass and herbage representing fodder or uprooted weeds of the barley crop. Significant proportions of Wild turnip, heather, sedges (*Carex* spp.), grasses (Poaceae undiff.), Ribwort plantain and Curled dock were recovered. Smaller proportions of Chickweed, Heathgrass, Common spike-rush, Common fumitory, Pale persicaria, Knotweed, Tormentil, Creeping buttercup, Sheep's sorrel, Charlock (*Sinapis arvensis* L.) and violet were also quantified. Potentially gathered berries and nuts included Bearberry, hazelnut, Crowberry and Bilberry and a single seed of Rowan suggested a local presence of this shrub that is now found in isolated cliffs and ravines in modern day Lewis (Pankhurst & Mullin, 1994).

Special deposits

Two samples (S.129 & S.229) contained a large number of cereal grain and chaff fragments, as well as wild components dominated by moorland and arable habitats. Sample 229 was taken from *in situ* hearth material from one of the cells and the other sample was taken from *in situ* burnt material within a whalebone vertebra. The plant material seems to have been burnt deliberately in the vertebra as an act of closure of one of the cells (Harding & Gilmour, 2000), perhaps investing meaning in the form of the agricultural cycle to the life cycle of the structure. The ritual implications of this deposit are investigated in more detail in Section 6.5 below.

Both sets of deposits contain significant proportions of chaff and wild components allowing insights into crop harvesting and processing not possible from the deposits rich in grain or mixed wild components that characterise many of the samples from the domestic blocks. The findings from these two samples are discussed and compared to similar deposits from the other two Bhaltos peninsula sites (Dun Bharabhat and Cnip) in Section 7.2.

6.3.10 Galson Late Iron Age block (**GAL-LIA**)

Taphonomy

Following standardisation two macrofossil and four charcoal samples remained. Mineral magnetic analysis (Section 5.4; Peters *et al*., 2000) and soil micromorphology (Tams, forth.) suggested that much of the charred material stemmed from the spread of ash from the hearth and ash pit in the two structures from which the samples were taken. Fuel sourcing through detailed mineral magnetic analysis suggests that the main fuel source was well humified peat (Section 5.8).

Carbonised plant material

The macrofossil concentration (mean QC/litre) and charcoal concentration (charcoal fragment & weight/litre) were within the normal range of domestic blocks. The total assemblage (n=54) was dominated by grain (61%), with some wild components (33%) and a little chaff (6%). Again, the block assemblage was based on only two samples so only limited inference can be made from the basic composition of the assemblage.

Only 12 charcoal fragments were recovered from the block consisting of some pine and oak timber and roundwood of birch and Ling heather. The identifiable cereals were also small in number (n=30) and consisted of four naked asymmetric grains, indicating the presence of the six-species, and 11 hulled grains, of which seven were asymmetric, again indicating the presence of the six-row species. The chaff consisted of three large culm bases. Only 18 wild components were recovered, consisting of 15 small culm parts and rhizomes, two indeterminate seeds and a knotgrass seed.

6.3.11 Bostadh early block and 'figure-of-eight' occupation (**BO-E; BO-LIA**)

Taphonomy

Following standardisation, only one macrofossil and eight charcoal samples remained from the Early block, whereas 80 macrofossil and 130 charcoal samples remained from the Late Iron Age block. Only nine charcoal samples were analysed from this block following a 10% random selection of the samples that were available for analysis following standardisation. This random sample was taken due to time constraints. Mineral magnetic analysis (Section 5.4) and soil micromorphology (Tams, forth.) suggested that much of the charred material stemmed from the spread of ash from the hearths located throughout the settlement. Fuel sourcing through detailed mineral magnetic analysis suggests that the main fuel source was well- humified peat (Section 5.8).

Carbonised plant material

Only 10 macrofossil and two charcoal identifications were made from the single Early sample and the identifiable material included seven barley grains, of which three were hulled, single seeds of Curled dock, dock, a small culm node and a fragment of Ling heather charcoal. Conversely, the 80 samples from the Late Iron Age block contained the largest assemblage in the study with 17948 identifications.

The macrofossil concentration (mean QC/litre) and charcoal concentration (charcoal fragment & weight/litre) were within the normal range of domestic blocks. The total assemblage was dominated by grain (82%), with some wild components (14%) and a little chaff (4%).

Only 35 charcoal identifications were made from the nine charcoal samples. These included a significant proportion of Ling heather. Lesser proportions of birch and willow roundwood were recovered, along with timber of birch, larch, spruce and pine. All of the deciduous species would have been available locally at the time and the exotic conifers and some of the pine is likely to have been collected as driftwood.

14622 grain identifications were made. Of the identifiable cereal, 88% was barley, 10% flax, 1.5% oat and less than 0.2% of wheat and rye. Turning first to the barley (n=10436), 68% was hulled (n=7058) and less than 1% was naked (n=67). The ratio of symmetric:asymmetric naked grain was 1:1.8 (n=17) suggesting a predominance of the six row species. The ratio of symmetric:asymmetric hulled grain was 1:1.7 (n=3336) suggesting a predominance of the six-row species but with a smaller proportion of the two-row species. This pattern was also supported by the identification of 42 six-row rachis internodes with only a couple of the two-row species. 1222 flax seeds were also recovered from almost 40% of the samples. This suggests flax cultivation was practised for the first time during this block. The 158 oat grains from over 40% of the samples also suggest that oat was cultivated for the first time, supported by the recovery of two cultivated oat floret bases. These chaff fragments are very fragile and do not usually survive the carbonisation processes in household fires (Boardman & Jones, 1990). The relatively small amounts of wheat (n=44) and a single grain of rye are likely to represent weed contaminants of the barley, oat and flax crops rather than crops grown in their own right. The only other chaff fragments were some large culm nodes (n=23) and a higher proportion of large culm bases (n=599).

A large variety of wild components (n=2658) was recovered. These could have grown in a wide range of habitats. The largest group of identifiable remains was again the small culm parts and rhizomes. In descending order of frequency in terms of the proportion of the wild components, the species recovered included grasses (Poaceae undiff.), Curled dock, Corn spurrey, Wild turnip, sedge (*Carex* spp.), Common spike rush, knotgrass, dock, Common nettle, Fat hen, Sheep's sorrel, Ribwort plantain, Pale persicaria, Chickweed, heather, Heath grass, Bearberry, Crowberry, Common hemp nettle, Blinks, Creeping buttercup, buttercup, Marsh woundwort, Clover, violet, Bugle (*Ajuga reptans* L.), Black-bindweed (*Fallopia convolvulus* L. A. Love), Common fumitory, Cleaver (*Galium aparine* L.), Redshank, Bulbous buttercup, Wild radish and Common sorrel. The moorland species could have been incorporated into the domestic hearths as part of the well-humified peat or as fuel with heather and sedges. Moorland species such as heather, Bearberry and Crowberry may also have been gathered in their own right. The damper species could have stemmed from fodder or internal furnishings and the disturbed ground and arable indicators as weed contaminants of the crop.

Special deposits

A number of samples contained large numbers of burnt grain, chaff and wild components. With the taphonomic problems in mind it might be possible to assess the wild components for possible weed contaminants that would then allow the soil conditions of the fields to be assessed. Also, the relatively high concentrations of Corn spurrey in this block compared to the other domestic assemblages seems to correlate with a number of samples with significant caches of burnt flax. This may indicate a slightly different weed ecology in free-draining light soils (machair) for the flax crop than the barley and oat crop. These concepts are explored in more detail in Section 7.2.

6.3.12 Loch na Beirgh 'figure-of-eight' occupation (**LB-LIA**)

Taphonomy

Following standardisation, four macrofossil and charcoal samples remained. All the samples were generic occupation contexts with significant magnetic enhancement (Section 5.4), indicating the carbonisation of the material probably occurred within the central domestic hearth. Fuel sourcing through detailed mineral magnetic analysis suggests that the main fuel source was well humified peat (Section 5.8).

Carbonised plant material

The macrofossil concentration (mean QC/litre) and charcoal concentration (charcoal fragment & weight/litre) were within the normal range of domestic blocks. The total assemblage (n=181) was dominated by grain (76%), with some wild components (20%) and a little chaff (4%).

32 charcoal identifications were made with a significant proportion of Ling heather, with some birch and hazel roundwood and timber of birch and fir. The deciduous genera were all available locally and the fir was certainly driftwood.

The identifiable cereals (n=128) were dominated by barley (71%), with some flax (25%) and a little oat (3%) and wheat (1%). Where identification was possible, all the barley was hulled, with the ratio of symmetric:asymmetric hulled grain of 1:2.3 pointing to the predominance of the six-row species. No rachis internodes were recovered to verify this pattern and the only chaff present was seven large culm nodes. The significant proportion of flax, present in two of the four samples, suggests cultivation was practised though this is not as certain for the low amounts of oat, which could just represent weed contamination of the barley or flax crop.

Only 37 wild components were recovered with some small culm bases and rhizomes, heather, sedge (*Carex* spp.), Redshank, grasses (Poaceae undiff.), knotgrass, Corn-spurrey and single seeds of mustard / charlock, Common sorrel, Sheep's sorrel, Curled dock and Chickweed.

6.3.13 Bostadh Late Iron Age / Norse transition (**BO-LIA/N**)

Taphonomy

Following standardisation, 26 macrofossil and 31 charcoal samples remained. Only 10 charcoal samples were analysed from this block following a 50% random selection of the samples that were available for analysis following standardisation. This random sample was taken due to time constraints. Mineral magnetic analysis (Section 5.4) and soil micromorphology (Tams, forth.) suggested that much of the charred material stemmed from the spread of ash from domestic hearths, though none were located on the site for this block. Fuel sourcing through detailed mineral magnetic analysis suggests that the main fuel source was well humified peat (Section 5.8).

Carbonised plant material

The macrofossil concentration (mean QC/litre) and charcoal concentration (charcoal fragment & weight/litre) were within the normal range of domestic blocks. The total assemblage was dominated by grain (69%), with some wild components (25%) and a little chaff (6%).

75 charcoal fragments were identified with significant proportions of Ling heather and spruce timber. The deciduous material included roundwood of birch and Pomoideae undifferentiated and timber of alder and birch. The coniferous material consisted of pine roundwood and timber of larch and pine. All of the deciduous species would have been available locally at the time and the exotic conifers and perhaps some of the pine is likely to have been collected as driftwood. However, the presence of pine roundwood may also represent locally available pine.

The identifiable cereals were dominated by barley (94.7%), with some oat (4.6%) and a little wheat (0.4%) and flax (0.3%). The barley (n=2268) consisted of 68% hulled (n=1548) and 2% naked (n=49). The ratio of asymmetric:symmetric naked grain was 1.1:1 (n=15) suggesting a mix of two and six-row species. The ratio of symmetric:asymmetric hulled grain was 1:1.5 (n=545) also suggesting a predominance of the six-row species but with a significant proportion of the two-row species. However, this pattern was not wholly supported by the eight six-row rachis internodes compared to the single two-row rachis internode. Oat was present in sufficient quantities (n=110 in over 40% of the samples) to suggest cultivation, supported by the recovery of two floret bases of cultivated oat. However, the small amount of flax seeds (n=7 in 15% of the samples) raises doubts over significant cultivation at this point. It is likely that the wheat (n=10) represented a weed contaminant of the barley or oat crop. The remaining chaff consisted of large culm nodes and bases.

A variety of wild components (n=988) were recovered that could have grown in a wide range of habitats. The largest group of identifiable remains was again the small culm parts and rhizomes. In descending order of frequency in terms of the proportion of the wild components, the other species recovered included Curled dock, sedge (*Carex* spp.), knotgrass, dock, grasses (Poaceae undiff.), Sheep's sorrel, Wild turnip, mustard / charlock, Heath grass, Ribwort plantain, Fat hen, Common spike-rush, Common sorrel, Chickweed, heather, Corn spurrey, Crowberry, Creeping buttercup, violet, Common fumitory, Tormentil, Bulbous buttercup, buttercup and Wild radish. The moorland species could have been incorporated into the domestic hearths as part of the well-humified peat or as fuel with heather and sedges. Moorland species such as heather and Crowberry may also have been gathered in their own right. The damper species could have stemmed from fodder or internal furnishings and the disturbed ground and arable indicators as weed contaminants of the crop.

Special deposits

A number of samples were analysed that contained large numbers of burnt grain, some chaff and wild components. With the taphonomic problems in mind it might be possible to assess the wild components for possible weed contaminants that would then allow the soil conditions of the fields to be assessed. This concept is explored in more detail in Section 7.2.

6.3.14 Bostadh Norse block (**BO-N**)

Taphonomy

Following standardisation, 11 macrofossil and 16 charcoal samples remained. Mineral magnetic analysis (Section 5.4) and soil micromorphology (Tams, forth.) suggested that much of the charred material stemmed from the spread of ash from domestic hearths, though none were located on the site for this block as the coastal erosion had removed much of the interior of the rectilinear structure. Fuel sourcing through detailed mineral magnetic analysis suggests that the main fuel source was well humified peat (Section 5.8).

Carbonised plant material

The macrofossil concentration (mean QC/litre) and charcoal concentration (charcoal fragment & weight/litre) were within the normal range of domestic blocks. The total assemblage (n=1726) was dominated by grain (89%), with few wild components (9%) and chaff (2%).

63 charcoal fragments were identified with significant proportions of Ling heather, birch roundwood and timber. Some fragments of hazel roundwood and timber of willow, larch, spruce and pine were also recovered. All of the deciduous species would have been available locally at the time and the exotic conifers and perhaps some of the pine was likely to have been collected as driftwood.

The identifiable cereals were dominated by barley (72.1%), with a significant proportion of oat (26.3%) and a little flax (0.9%), wheat (0.4%) and rye (0.3%). The barley (n=940) consisted of 61% hulled (n=571) and 2% naked (n=16). The ratio of symmetric:asymmetric hulled grain was 1:1.8 (n=179), suggesting a predominance of the six-row species with the possible presence of the two-row species. However, this pattern could not be verified from the chaff as no rachis internodes were recovered. Oat was present in sufficient quantities (n=343 in over 70% of the samples) to suggest cultivation, supported by the recovery of a floret base of cultivated oat. However, the small amount of flax seeds (n=12 in 36% of the samples) raises doubts over significant cultivation at this point. It is likely that the wheat (n=4) and rye (n=3) represented a weed contaminant of the barley or oat crop. The remaining chaff consisted of large culm bases. A single seed of Common vetch was also recovered from the Norse midden, raising the intriguing question of its possible cultivation or trade as an exotic foodstuff.

A smaller number of wild components (n=152) were recovered from the Norse block than the two earlier blocks from Bostadh. However, the remains recovered could still have grown in a wide range of habitats. The largest group of identifiable remains was again the small culm parts and rhizomes, with significant proportions of grasses (Poaceae undiff.), knotgrass, Curled dock and Corn spurrey. Smaller proportions of Bearberry, Wild turnip, sedge (*Carex* spp.), Fat hen, Heath grass, Crowberry, Cleaver, Ribwort plantain, Bulbous buttercup, Creeping buttercup and Bilberry were also recovered. The moorland species could have been incorporated into the domestic hearths as part of the well-humified peat or as fuel with heather and sedges. Moorland species such as heather, Bearberry, Bilberry and Crowberry may also have been gathered in their own right. The damper species could have stemmed from fodder or internal furnishings and the disturbed ground and arable indicators as weed contaminants of the crop.

Special deposits

Two samples were recovered that contained a large number of burnt grain with some chaff and wild components. With the taphonomic problems in mind it might be possible to assess the wild components for possible weed contaminants that would then allow the soil conditions of the fields to be assessed. Again, the presence of Corn spurrey seems to correlate with the presence of flax. This may indicate a slightly different weed ecology in free-draining light soils (machair) for the flax crop than the barley and oat crop. These concepts are explored in more detail in Section 7.2.

6.3.15 Galson Norse / Medieval block (**GAL-N/M**)

Taphonomy

Following standardisation 10 macrofossil and 14 charcoal samples remained. Mineral magnetic analysis (Section 5.4; Peters *et al.*, 2000) and soil micromorphology (Tams, forth.) suggested that much of the charred material stemmed from the spread of ash from domestic hearths in the main structural complex from which the samples were taken. Fuel sourcing through detailed mineral magnetic analysis suggests that the main fuel source was well humified peat (Section 5.8).

Carbonised plant material

The macrofossil concentration (mean QC/litre) was very high, second only to the conflagration horizon in Dun Bharabhat. This can be explained by the sampling of a midden very rich in macrofossils (Sample 2) that skewed the average of the small sample population. However, the charcoal concentration (charcoal fragment & weight/litre) was within the normal range of domestic blocks. The total assemblage (n=2129) was dominated by grain (83%), with a little wild components (14%) and chaff (3%).

Only 23 charcoal fragments were recovered including some Ling heather, a single fragment of birch roundwood and some timber of alder, birch, hazel, pine, spruce and fir. All of the deciduous species would have been available locally at the time, with a single birch seed from the macrofossil rich midden confirming its local presence. The exotic conifers and perhaps some of the pine was likely to have been collected as driftwood.

The identifiable cereals were dominated by barley (79.9%), with a significant proportion of oat (19.7%) and a little flax (0.1%), wheat (0.2%) and rye (0.1%). The barley (n=1091) consisted of 74% hulled (n=808) and 1% naked (n=6). The ratio of symmetric:asymmetric hulled grain was 1:1.6 (n=353), suggesting a predominance of the six-row species with some cultivation of the two-row species. The recovery of 12 six-row rachis internodes and two of the two-row species supported this pattern. Oat was present in sufficient quantities (n=269 in 80% of the samples) to suggest cultivation, supported by the recovery of a floret base of cultivated oat. However, the single flax seed raises doubts over significant cultivation of this species during this block. It is likely that the wheat (n=3) and rye (n=2) represented a weed contaminant of the barley or oat crop. The remaining chaff consisted of large culm nodes and bases.

Many of the 310 wild components came from the macrofossil rich midden (Sample 2) and covered a variety of habitats. The largest group of identifiable remains were again the small culm parts and rhizomes, with significant proportions of Wild turnip, sedges (*Carex* spp.), Heath grass, grasses (Poaceae undiff.), Curled dock and Chickweed. Smaller proportions of Spear-leaved orache, oraches, mustard/charlock, Fat hen, heather, Blinks, Ribwort plantain, knotgrass, Meadow buttercup, Bulbous buttercup, Sheep's sorrel, dock, Corn spurrey and Common nettle were also recovered. No evidence for the gathering of berried plants from the moorland was noted, unlike many of the other substantial domestic blocks in the study.

Special deposits

The macrofossil rich sample from the midden (S.2) contained a large number of burnt grain with some chaff and wild components. With the taphonomic problems in mind it might be possible to assess the wild components for possible weed contaminants that would then allow the soil conditions of the fields to be assessed. This concept is explored in more detail in Section 7.2.

6.3.16 An Dunan early Medieval block (**AD-M**)

Taphonomy

Following standardisation, three macrofossil and charcoal samples remained. These were sampled from a floor level and two associated ash spreads but the ephemeral nature of the occupation meant that no obvious hearth feature was noted. Despite this, the observed magnetic enhancement (Section 5.4) and soil micromorphology of the floor level (Tams, forth.) have been interpreted as indicative of the spread of ash from an unidentified burning episode. The spread of radiocarbon dates from the floor level and overlying fill (see Section 4.12) also show the potential for redeposition, presumably by worm action. Therefore, the results from this block have not been included in the analysis outlined in the following sections and chapters due to the taphonomic uncertainties of the accumulation of the assemblage.

Carbonised plant material

The macrofossil concentration (mean QC/litre) and charcoal concentration (charcoal fragment & weight/litre) were relatively low. The total assemblage (n=183) was dominated by wild components (61%), with some grain (32%) and a little chaff (7%). Only 20 charcoal fragments were identified, with a significant proportion of Ling heather, some pine timber and roundwood and a single fragment of spruce timber. The identifiable cereals were dominated by oat (94%) with a little barley. The oat (n=50) was assumed to represent the remains of cultivation but this could not be confirmed as no floret bases were recovered. The barley (n=3) included a hulled asymmetric grain, confirming the presence of the six-row species. The only chaff present included some large culm parts. 112 wild components were identified, again dominated by small culm parts and rhizomes. Small amounts of species from a variety of habitats were also recovered, including sedge, Heath grass, Common spike-rush, Ribwort plantain, grasses (Poaceae undiff.), knotgrass and buttercup.

6.4 The social dimension of plants

6.4.1 General

One of the interpretative research themes outlined in Chapter 2 involved using the archaeobotanical assemblages as indicators of the social landscape in terms of site function, as well as the less prosaic uses of plants within the belief systems of the populations. The archaeobotanical summaries of the blocks above have indicated differences in the concentrations and relative proportions of different plant species and classes, especially when comparing those assemblages from domestic sites with material from sites of a more specialist function. This section will explore the differences between the Mid Iron Age assemblages from Dun Bharabhat, Cnip, Guinnerso and An Dunan and attempt to explain them in terms of the different activities, and hence the different functions, of the sites. These assemblages have been chosen as they are broadly contemporary within the coarse dating scheme utilised in this study. The excavators of each of the sites have assigned a generic function to the blocks, hypotheses that can be tested by the plant assemblages. The blocks from Dun Bharabhat (Harding & Dixon, 2000) and Cnip (Armit 1996, forth. a) have been interpreted as being essentially domestic in character, with the Mid Iron Age block at Guinnerso seen as a possible transhumance site (Church & Gilmour, 1999) and the main block at An Dunan representing specialist funerary activity (Burgess *et al.*, 1997b, 1998a). All of the samples (except the single sample from the conflagration in Dun Bharabhat) had similar taphonomic histories, stemming from the incorporation of plant material from a variety of human activities into hearths and the carbonised remains then spread throughout the sites with the ash.

6.4.2 Past research into site function archaeobotany

Past attempts to differentiate site function using plant assemblages in Britain have concentrated on the identification of cereal production and consumption. Models were produced, based on ethnobotanical studies of crop processing (Hillman, 1981, 1984; G Jones, 1984, 1987), by which production or consumption of cereals were identified through the variable proportions of grain, chaff and weed seeds recovered from the sites. Hillman (1981) first identified cereal producer sites through the abundance of cereal chaff and the whole suite of crop-processing debris being recovered, whereas consumer sites would contain samples consisting of cereal debris of the final crop-processing and grain products. This model was challenged by Martin Jones (1985) through a case study of Romano-British sites in the upper Thames valley. He identified a number of sites on the wetter first Terrace where pastoral activity was prevalent, through structural evidence and complementary palaeoenvironmental sources such as beetle remains. These sites would have been classed as consumer sites in Hillman's model. He found that these pastoral sites were essentially cereal chaff rich whereas other sites on the higher and drier terraces, where arable agriculture was possible, were essentially grain rich. He displayed his results quantitatively through the use of triangular scattergrams and the cereal production / consumption criteria were the opposite to those proposed by Hillman.

The development of these competing models was an important theoretical and methodological step for archaeobotany in Britain. Firstly, it was seen as an interpretative advance from site based interpretations of arable agriculture to a wider analysis of the economic and social landscape. Also, the triangular scattergrams introduced by M Jones (1985) were very effective in presenting the basic composition of the samples within a site assemblage.

However, the theoretical, taphonomic and methodological assumptions underlying the producer / consumer models have received criticism from a number of researchers questioning the validity of their application. Van der Veen (1991, 1992) highlighted a number of problems including the essentially qualitative nature of Hillman's model, the complementarity of other proxy records needed for Jones' model and the over-simplification of site classification, using only the site labels of producer and consumer. She suggested a more detailed division of sites for the later prehistoric period grouped into subsistence production, production for surplus, small consumer sites and large urban complexes. Boardman & Jones (1990) highlighted the problem of differential preservation of various cereal parts that may have created the variable proportions in cereal remains rather than different crop-processing activities. Recently, Smith (2001) and Bakels (2001) attacked the theoretical assumptions underlying the models and Smith suggested that "these models are not just flawed, they simply do not work as reliable indicators of the economic activities of a site" (Smith 2001, 284). However, she acknowledged that the methodologies developed in the data presentation and comparison were valid, it was only the interpretations and labels placed on certain sets of remains that were flawed.

Elements of the methodology from the producer / consumer debate will therefore be used to compare the Mid Iron Age assemblages above. However, the interpretative models used to fit the data will not be invoked, nor the producer/consumer labels. The first presentation medium used is the triangular scattergram. The three classes of remains expressed in the scattergrams of M Jones (1985, 1996) and van der Veen (1991, 1992) were based on grain, chaff and weed seeds associated with the cereal crop. The taphonomic arguments outlined in Chapter 5 and the mixed plant assemblages from the blocks outlined above show that the material that would normally be classified as 'weed seeds' derive from a variety of habitats including arable fields, but also wet pasture and moorland. This again highlights the danger of the tendency of labelling all wild components as weed seeds of an arable crop in British archaeobotany. Therefore, the scattergrams presented here comprise the relative proportions of grain, chaff (including culm nodes and culm bases greater than 2mm in diameter that could be derived from cereals) and wild components (including culm nodes and culm bases less than 2mm in diameter that are likely to derive from wild grasses (Poaceae undiff.)). The other two sets of data to be compared are the macrofossil concentration (Quantifiable Component/litre) and cereal grain concentration (caryopsis/litre).

6.4.3 Comparing the assemblages

Figures 6.3 and 6.4 present the macrofossil and grain concentrations for 1) the domestic blocks from Dun Bharabhat and Cnip, 2) An Dunan and 3) Guinnerso in ascending order of magnitude. The single sample from the conflagration of the secondary structure in Dun Bharabhat is not included as the concentrations were much greater than all of the other values, a function of the taphonomy and nature of the deposit. It is clear that the samples from the domestic blocks had consistently higher macrofossil and grain concentrations than the two sites with specialist activity. Indeed, the samples with higher macrofossil concentrations from An Dunan (Samples 28 & 68) and Guinnerso (Samples 272, 308 & 373) were either very small in volume in the case of An Dunan or were dominated by the smaller culm bases and rhizomes that could have been introduced as part of the fuel source. Nearly all of the samples from the two specialist activity sites had very low grain concentrations apart from a single sample from An Dunan (Sample 28). However, this sample was again very small in volume that may overemphasise the concentration.

Figure 6.5 presents the triangular scattergrams for the domestic blocks, An Dunan and Guinnerso. It can be seen that the domestic blocks display the most variability, with a significant number of the samples cereal rich, two of the samples displaying significant proportions of chaff and the remaining three samples rich in wild components. Conversely, the two specialist sites are much more consistent in the sample composition. The samples from An Dunan are either dominated by wild components or tend towards a mix of wild components and grain. The samples from Guinnerso are almost all dominated by wild components with only very little chaff and grain.

6.4.4 Interpreting the patterns

It is proposed that the basic difference between the domestic blocks and the specialist activity sites reflect the differences in the human / plant interactions undertaken on the site that produce material that can be incorporated into the hearths and subsequently preserved. For example, a wide range of activities is undertaken within the domestic sphere that is reflected in the diversity of sample composition. A significant proportion of the samples is either cereal or chaff rich. Most of the samples also have a comparatively high concentration of grain. This can be interpreted as either the production or consumption of arable products being a significant part of the economy of the site. The important concept to appreciate is that cereal remains, whether grain products or processing residue, were routinely handled within the settlement. Both sets of materials have an economic value, whether as foodstuffs and seed in the case of the grain or as furnishings, thatch and fodder in the case of the straw and the chaff. Figures 6.6, 6.7 and 6.8 present the average macrofossil concentration, grain concentration and total assemblage composition for all of the domestic blocks with greater than 10 samples. These figures show the relative similarity between the domestic assemblages that implies a significant arable component in the economy of the sites. All of the domestic blocks contained several fragments and some whole quernstones, indicating at least subsistence level grinding of the grain.

Conversely, the low macrofossil and grain concentrations on the two specialist sites, coupled with the much more limited range of composition for the samples, suggests that crop products and debris were not routinely handled within the immediate vicinity of the hearth. Therefore the range of activities involving plants was probably less than the domestic sites. This implies that there was no significant arable component in the activities undertaken on the sites, supported by the absence of any quern stones, either re-used, broken or whole, during any period on the sites. In the case of Guinnerso, this would fit in with the hypothesis that the site was a small transhumance summer dwelling (a sheiling), where the economic activity was dominated by the production of dairy products and the provision of fodder for the herd. The low number of cereal remains recovered may relate to cooking accidents from the small amount of processed grain taken across to the moorland site in the summer. The wild components may relate to material gathered from the surrounding moorland, such as various berried plants and heather, or were incorporated as part of the fuel or perhaps fodder thrown in the fire.

An alternative hypothesis could be proposed for the site as a previously unrecognised class of monument in the mid Iron Age, ephemeral and unspectacular, that differs in its archaeological visibility and landscape position to the monumental Atlantic roundhouses and wheelhouses. Perhaps, Guinnerso represents the dwellings of a lower social class, subservient to the Atlantic roundhouse and wheelhouse dwellers, who are forced to live in the most marginal areas of the landscape and have little access to the workings of the regional arable economy, relying instead on the provision of a pastoral surplus to exchange for the small amount of processed grain. In this context, it is interesting to note that one of the samples contained some oat grains that may represent extremely small-scale cultivation within the marginal blacklands. More evidence of this cultivation may not have been recovered as the amount of material handled in and around the site was not sufficient to have an archaeological signature preserved in the hearth. Also oat chaff is easily destroyed in domestic hearths (Boardman & Jones, 1990). However, the lack of any quernstones seems to suggest that arable agriculture or consumption did not play any significant role in the economy of the site's inhabitants, a difficult position to argue for a permanent domestic dwelling in the British Iron Age. More analysis of the other sets of ecofacts and artefacts are needed to evaluate these hypotheses further, but it is the view of the author that the initial hypothesis of the site for summer transhumance is supported by the archaeobotanical evidence.

An Dunan again contained very low concentrations of macrofossils and grain, with the composition of the samples split between wild component and grain dominated. The wild components were likely to stem from the fuel and other combustible material burnt in the elaborate hearth, whereas the presence of low numbers of grain can be interpreted as an act of structured deposition. The investigation of these deposits at An Dunan and a number of other sets of deposits that relate to funerary activity and other forms of structured deposition will now be undertaken to address the importance of plants in belief and ritual.

6.5 Plants and belief systems

It has been argued that two of the sites sampled, Calanais kerb cairn and the main block at An Dunan, represent sites where funerary activity dominated (Sections 4.8 and 4.12). Large spreads of burnt material were sampled at each site and the point of carbonisation, in the form of a large elaborate hearth, was identified in the centre of An Dunan. Mineral magnetic analysis (Chapter 5) has indicated the type of fuel burnt and the spreading of this material. Distinctive suites of carbonised remains were recovered from each site. It is argued that the plant material was selected deliberately to be burnt as part of the funerary ceremonies and therefore invested with meaning, reflecting aspects of the belief systems of the people.

At Calanais kerb cairn, most of the carbonised plant macrofossils were recovered from the ash spreads across the interior of the cairn, representing redeposited ash from the burning of peaty turves, perhaps as part of a funeral pyre or feasting ceremony connected to the closure of the cairn. Section 6.3.2 summarised the plant remains from the ash spreads, highlighting the presence of some cereals, a little chaff and a large proportion of the assemblage derived from wild components. The mix of habitats covered by the wild components can be interpreted in a number of ways. Firstly, the damp, acidic indicators may have been introduced into the assemblage through the peaty turf fuel. Also, the mix could represent different areas of cultivation for the hulled and naked barley. Alternatively, it may represent grassland material from areas used for pastoral activity. The material was incorporated into both the fire to be burnt and interleaved with the ash spreads in the body of the cairn and could have been used for fodder. Milburn (2001) noted that the pollen spectra from these decomposed plant levels contained evidence of moorland and damp grassland species (see Section 6.3.2 above). Again, this may represent accidental incorporation but may also be an example of structured deposition, a metaphoric link symbolising the importance of pastoral activity in the physical, economic and social landscape of the human group. The use of peaty turf from an area of rough grazing may also be part of this symbolic incorporation. It is interesting to note the presence of a few seeds of Bilberry and Cowberry within the ash spreads, especially within the top fill of the central cist. Both types of berries would have been a component part of the wild moorland plant gathering in late summer / early autumn, i.e. harvest time (see Section 7.4).

This mixing of plant material in the carbonised assemblage means detailed archaeobotanical interpretation is greatly complicated. However, the incorporation of material relating to various aspects of the plant economy into a fire associated with the ceremony and closure of the kerb cairn must be explained. It may represent the accidental incorporation of the material within the peaty turf fire, or more structured deposition expressing elements of the seasonal and annual economic cycle into the society's belief system. It can be envisaged that four aspects of the plant economy are being incorporated into the body of the cairn; the crops, fodder, gathered berries and the hinterland zone of peaty turf, presumably for rough grazing. This could represent a wide range of facets within the belief system including aspects of fertility and rejuvenation, annual cycles of plant husbandry and use and the importance of prosaic economic needs in expressing death and closure.

Plant macrofossil assemblages from Bronze Age funerary deposits in Scotland are rarely sampled, though assemblages dominated by culm bases and nodes of cereal/monocotyledon type were recovered from cremation pits at Seafield, Aberdeenshire (Church, in press). Samples from within a funeral pyre in a cairn at Sketewan, Perthshire, produced mostly alder charcoal, with some evidence of the burning of grassy material from abandoned cultivated ground or grassland (Dickson, 1997). A number of assemblages have also been analysed from ash spreads associated with burnt mounds in

Atlantic Scotland (cf. Church, unpubl b; Holden, 1999) that also contained evidence of heather charcoal and small culm bases and rhizomes. These assemblages presumably represent material either incorporated within the fuel source (turf or peat) or the burning of grasses (Poaceae undiff.) and weeds from cultivated land or hay during the cremation, again through accidental burning or a form of structured deposition. Hence, the limited incorporation of material from different aspects of the agricultural cycle into Bronze Age funerary pyres is beginning to emerge from the Scottish evidence and is consistent with the pattern across Britain (Robinson, 1988).

The plant material from An Dunan was more poorly preserved from that in the ash spreads at Calanais kerb cairn but again contained deposits with some grain and also some wild components. The deposits with the most grain were *in situ* hearth material or ash spreads immediately associated with the hearth so it seems likely that cereal products were deliberately incorporated into the hearth as part of the funerary activity. A single flax seed was found in one of the ash spreads (Sample 47) with other barley grain and may represent the deliberate burning of an exotic cultivated plant, perhaps traded from elsewhere within the Atlantic continuum. The single fragment of Purging buckthorn roundwood within an *in situ* hearth level containing cremated human bone is also particularly interesting within the context of the deliberate structured deposition of exotic plants.

Purging buckthorn is considered doubtfully native in Scotland (Godwin, 1975) and grows in wet woods in chalk and limestone areas. Its present range within the British Isles is concentrated in the south and east, with its most northerly habitat found around Morecombe Bay in Lancashire (Taylor, 1999). A twig is unlikely to be of much use economically and would only last a short while in the sea for it to be collected randomly as driftwood. Therefore its position in direct association with funerary activity suggests some form of structured deposition and deliberate procurement. Another single fragment of uncarbonised Purging buckthorn was found in waterlogged deposits stratigraphically earlier than the Atlantic roundhouse at Dun Vulan, identified by Maisie Taylor (1999). She noted its associations with witches and magic powers in Medieval literature in Holland. Therkorn *et al.* (1984) also noted the apparent non-functional positioning of the species within an Early Iron Age domestic structure in Assendelft, Holland. Is it possible that Purging buckthorn was exchanged across the Atlantic continuum as something approximating to a good luck charm or symbol of magical powers?

Mineral magnetic analysis (Section 5.8) demonstrated that well-humified peat was used as the main cremation fuel, compared to the peaty turf used in Calanais kerb cairn a millennium before. Well-humified peat was the standard fuel type of the Mid Iron Age and represents procurement and management of resources within the marginal blackland zone. Seeds of Crowberry and Bilberry were also found in the hearth material and ash spreads associated with the central hearth. This may represent structured deposition of those berries collected from the blacklands. The probable transhumance site of Guinnerso also shows the increased economic importance this zone had within the economic landscape of the Mid Iron Age and the well-humified peat and berries burnt on the hearth could be interpreted as a conscious effort to link this marginal zone to the funerary ceremonies undertaken on the site.

Hingley (1992) stressed the continuum between the domestic sphere and belief systems in the Scottish Iron Age, with structural components invested with symbolic meaning as well as serving a utilitarian purpose. For example, well-humified blanket bog peat was used to create a level surface or foundation on which the Cellular phase at Loch na Beirgh was built (Harding & Gilmour 2000, p42). The seasonally waterlogged nature of the deposits at this depth in the excavations meant the peat was easily identified and the foundation level was largely sterile, apart from some material that had becoming pressed into it through trampling. The nearest extensive source for the well-humified peat of this nature would have been a couple of kilometres away on the Uig Peninsula and so would have required a substantial investment of labour to cut, dry and transport. This foundation layer for a new settlement may represent another conscious effort to forge a physical and metaphoric link from the domestic core to the hinterland moorland zone (cf. Hodder 1990, 83-87) in the initial stages of the life cycle of the rejuvenated settlement.

Another aspect of the economic landscape, in the form of arable agriculture, was also part of a closure ceremony for one of the cells in the Cellular block at Loch na Beirgh (Harding & Gilmour 2000, p33-4). The ceremony involved the clearance of the area and the spread of an ash rich layer full of pottery across the central area of the cell. A whalebone vertebra, hollowed out for a flat stone that was placed in its base, was set into this spread of ash and a small fire burnt in the whalebone feature. This was sampled (Sample 171) and it contained a large, relatively well-preserved assemblage of barley grain, chaff and wild components dominated by weeds of cultivation and some moorland species that could have come from the fuel source. The burning of what appears to be the residue from a crop-processing stage in such a structured way strongly suggests incorporation of arable agriculture into the belief systems of the inhabitants.

At this juncture it is important to raise a note of caution concerning the identification of structured deposition within the archaeological record. The identification of this behaviour relies on a deposit's association with funerary activity (e.g. Calanais kerb cairn and An Dunan) or the relationship to abnormal sets of features in domestic sites (e.g. the whalebone vertebra or peat foundation layer at Loch na Beirgh). These deposits are relatively rare within the total sample population of this study, in which the majority of the samples represent a mix of human behavioural episodes of discard into domestic hearths. The role of structured deposition should therefore not be overemphasised, a danger within the theoretical climate of present Iron Age studies in Britain.

However, a number of points can be raised concerning the examples of structured deposition outlined above. There appears to be the repeated practice of incorporating elements of the economy into the burning events associated with funerary activity. The incorporation may be deliberate or unconscious in the form of fuel. If conscious selection is being exercised then what symbolic meaning is being invoked? A possible mode of thought could be the creation of a metaphoric link to the wider economic landscape and annual agricultural cycle that is being included in the passing of the dead from the known landscape to the afterlife.

The incorporation of exotic plant material into the hearth at An Dunan also provides evidence for exchange networks of rare products over long distances for use in less prosaic human activity. These products are not only plant materials but also can include the exchange of artefacts, such as the intact shale bracelet of material not found in the Western Isles inserted into one of the walls at An Dunan, or the exchange of animals, shown by the incorporation of the Barbary ape skull into the centre of the massive ritual structure of Iron Age date at Emain Macha in Ireland (Raftery 1994, 79).

By the Mid Iron Age the domestic and funerary spheres are less well-defined with evidence of belief systems incorporated into the life cycles of structures as well. Again, metaphoric links to the wider landscape are forged with the creation of the foundation layer of well-humified peat in the machair loch of Loch na Beirgh a good example. Roof conflagrations may also signal important periods in the life cycles of structures that may not just represent an accidental fire, a concept explored in more detail in Section 8.3.

6.6 Conclusion

Through the comparison of the basic composition of the plant remains from the Mid Iron Age blocks, it has been possible to begin to assess aspects of the use of plants across the contemporary landscape. A wide diversity of activities relating to the use of plants seems to have occurred on the domestic sites. These sites probably represent the permanent homesteads where the products of arable economy, including straw, chaff and grain, were routinely handled. Guinnerso and An Dunan represent sites within the wider economic and social landscape where more specialist activities were practised, with a concomitant reduction in the amount of plant material carbonised. It has been argued that Guinnerso could represent a transhumance site for summer grazing. Arable agriculture played a very minor part in the economy of the site with very few arable remains recovered. An Dunan could represent a funerary site, where aspects of the wider economic and social landscape were incorporated into the elaborate central hearth as part of structured deposition accompanying human cremation.

It was envisaged that more detailed comparison between contemporary sites would have been possible in this study but only a limited comparison was undertaken due to sampling and chronological differences. Unfortunately all of the domestic blocks of the Mid Iron Age were sampled prior to 1995 and so relatively few samples were taken and only on a judgement basis (see Section 3.2). On the other hand, the contemporary sites of An Dunan and Guinnerso were total sampled, as were nearly all of the other domestic blocks. However, these other blocks were of many different ages that produced a broad chronological coverage but with little contemporaneity. Therefore, much of the discussion in the next chapter of the other three interpretative themes consists of evidence of certain site activities at any one point and the way these activities develop and change over time.

Chapter 7: Archaeobotany of West Lewis II: cereal agriculture, wood procurement and wild plant gathering / management

7.1 Introduction

This chapter presents a series of chronological narratives and specific case studies for the three main interpretative research themes outlined in the introduction. The first theme assesses aspects of the arable agriculture from the evidence recovered from the sites, with the second theme concentrating on the procurement and management of wood through analysis of the charcoal remains. The final theme addresses the role of the deliberate gathering of plant material from various habitats across the landscape. The final section then proposes an economic landscape and annual cycle for the plant economy during the first millennia.

7.2 Cereal agriculture

7.2.1 General

Four questions have been formulated concerning aspects of the arable economy. These questions are relatively straightforward due to the nature of the taphonomically mixed assemblages recovered from the sites, which precluded more detailed analysis. They include:

1) "What crops are found on the sites and does this change over space and time?"

2) "Where were the crops grown?"

3) "How were the crops processed?"

4) "What were the crops used for?"

7.2.2 "What crops are found on the sites and does this change over space and time?"

A question of cultivation

Before assessing the crop composition from the sites, it is important to consider the issue of cultivation. There is a danger in assuming the recovery of cereal remains automatically equates to cultivation of that crop being undertaken by the inhabitants of the site. In all probability, this assumption is usually correct as most people by the Iron Age in Atlantic Scotland would be engaged in a form of mixed farming and were likely to be growing crops in fields near to their permanent settlements. However, the presence of cereal remains only demonstrates that straw, crop-processing debris and/or grain products were handled near the domestic hearths. The increased probability of cultivation occurs with supporting lines of evidence. The first line of evidence is local scale contemporary pollen sequences that contain significant cereal pollen, such as Loch Bharabhat and Loch na Beirgh (Figures 4.3 & 4.4). Both indicate barley cultivation within the immediate catchment of the sites during their occupation (Lomax, 1997: Lomax & Edwards, 2000). The second line of supporting evidence is contemporary field systems close to the site of a type that could be used for cultivation (cf. Rosinish in Benbecula: Shephard & Tuckwell, 1977) and/or relic soil with evidence of cultivation practices (cf. Old Scatness in Shetland; Simpson *et al.*, 1998). However, no evidence of contemporary field systems has been found near any of the sites that make up this study. Another line of evidence is the presence of artefacts on the site that have specific functions within the arable process. These include querns, plough / ard shares and perhaps sickles.

Table 7.1 presents the presence or absence of these various lines of evidence for all of the non-funerary blocks in the study. The presence of various classes of carbonised remains is presented in the form of Ubiquity scores from Table 6.6, following the methodology established by Popper (1988). Nearly all of the blocks have very high percentage scores for grain and large culm bases, with slightly lower scores for the more fragile culm nodes and barley rachises. Cultivated oat florets appear only in those blocks with significant numbers of oat grains, such as the main blocks at Bostadh. This means that cereal debris and products were routinely handled within the domestic settlements. Of those sites with immediate local pollen coverage (Dun Bharabhat, Loch na Beirgh, Cnip and Guinnerso), only the spectrum from Loch Ruadh Guinnerso shows no cereal pollen contemporary with the occupation of the site. This supports the hypothesis proposed in Section 6.4 that the three sites on the Bhaltos peninsula represent permanent domestic homesteads engaged in cereal cultivation, whereas Guinnerso was a summer transhumance site with no arable cultivation and little use of cereals judging by the absence of quern stones. The presence of quernstones in most of the other blocks suggests that grain was probably ground during the occupation. The lack of quern stones at Galson and the early block at Bostadh are a function of the section sampling at Galson that was unlikely to recover ground stone tools and the very small area excavated at Bostadh relating to that phase. It is interesting to note the absence of querns at Gob Eirer in spite of a high Ubiquity count of cereal remains from the area excavation of over 65 m^2. This may be a function of the relative difficulty in identifying saddle querns compared to rotary querns on this Early Iron Age site before the quern transition. Alternatively, it may indicate that the barley was not ground but used in a slightly different way than in the later domestic blocks. However, the presence of querns does not necessarily equate to cultivation, only the grinding of grain that could have been traded and exchanged from elsewhere. Also, it has been argued (cf. Hingley, 1992) that the recovery of quernstones in Iron Age domestic contexts may be reflecting abandonment practices and/or structured deposition rather than *in situ* grinding, so caution must be exercised when interpreting the significance of quernstones to activities associated with arable production and consumption.

Very few artefacts relating to actual cultivation were recovered. These included a single metal ploughshare from the wheelhouse block at Cnip, and various antler picks and handles from the machair sites of Cnip, Bostadh and Loch na Beirgh that could have been used in the fields. The review in Chapter 2 of artefacts relating directly to cultivation, such as plough / ard shares, plough pebbles, shovels and sickles, demonstrated that most are very rare in a domestic setting in the Iron Age of Atlantic Scotland. This is a function of their preservation in the case of the metal objects. Also all these artefact types would have been used in the fields and so were unlikely to be deposited in the dwelling, unless as an act of structured deposition.

So in terms of cultivation, it seems likely that the inhabitants of the Bhaltos sites (Dun Bharabhat, Cnip and Loch na Beirgh) were cultivating barley, from a) the range of archaeobotanical material on the sites, b) the local pollen record and c) the presence of some artefacts relating to arable agriculture. It is also probable from the range of archaeobotanical remains and bone artefacts from Bostadh that cultivation of barley, oat and flax was also undertaken. No supporting evidence exists for the range of archaeobotanical remains at Gob Eirer and Galson and so the probability for cultivation is less than at the other sites. However, it is obvious that arable material was handled during the occupation of all the domestic blocks. Therefore it can be assumed that the remains reflect the type of material grown somewhere within the economic landscape of the site, the key concept for constructing chronological narratives of crop use on a regional scale.

The regional picture over time

Figure 7.1 presents the proportions of identifiable cultivated seed/grain (excluding the 'cereal indeterminate' class) for each of the blocks with at least 10 grains. Figure 7.2 presents the Ubiquity scores for each identifiable cultivated genera from each site block with at least 10 samples. An arbitrary cut-off point of 10 was chosen for much of the analysis in this chapter, to allow ready conversion to percentages for the samples and to maintain consistency with the initial standardisation outlined in Section 3.3.4. A number of key points can be highlighted, each of which will be explored in more detail below. Firstly, barley dominated the assemblages with only significant proportions of oat and flax appearing towards the end of the first millennium AD. Each of the domestic blocks with greater than 10 samples and Calanais kerb cairn had almost 100% Ubiquity scores of barley, with only the specialist sites of An Dunan and Guinnerso having lower scores of approximately 70%. This creates the impression of a barley monoculture in operation for much of the first millennia. Secondly, significant proportions of oat appeared in the late first millennium AD. A gradual increase in the importance of oat can be inferred from both the increases in the proportion of the assemblage totals and the Ubiquity scores. Thirdly, flax only appeared in significant quantities at the end of the first millennium AD, but its presence did not follow the progressive increase of oat. Finally, wheat and rye made up less than 1% of the total assemblages for all the blocks and were likely to be weed contaminants or perhaps reflecting very small scale exchange of grain produce.

A barley monoculture?

It is tempting at first to view the arable economy of the first millennia being dominated by a barley monoculture, with fields of identical crops being grown across the region. This view has been supported through the findings of the few published archaeobotanical reports from the Western Isles, such as Dun Vulan where "barley was the dominantly represented crop from the Early Iron Age phases until the abandonment of the broch in the Medieval period" (Smith 1999, 298). On most sites where further identification has been possible, the barley has been identified as the hulled variety and the rachis internodes and ratio between symmetric:asymmetric grain indicate the six-row species (see Section 2.5.14). The evidence from this study supports this assertion of the dominance of six-row hulled barley but also hints at other types of barley being cultivated.

Turning first to the varieties, naked and hulled barley present different advantages and disadvantages for their use. Naked barley is more easily processed, as the lemma and palea enclosing the grain are only loosely attached and so can be more easily removed. In hulled barley, the lemma and palea are more tightly attached or fused to the grain. In general, further crop-processing stages are needed to dry the hulled grain, usually through the singeing of the ears and gently grinding it to remove the hulled material, a process called 'graddening' in the recent past in the Northern Isles (Fenton, 1982). So more labour is invested in hulled barley processing than naked grain. However, because of the protection afforded by the tightly enclosing lemma and palae, hulled barley is much more resistant to dampness, premature sprouting and mould. This is an important factor for cultivation and storage in Northern Britain (van der Veen, 1992).

Figure 7.3 presents the ratio of hulled and naked barley from each site block with at least 10 grains identifiable to variety. Figure 7.4 presents the Ubiquity scores for hulled and naked barley from each site block with at least 10 samples. Again this shows the overall proportional dominance of hulled barley, with most blocks made up of almost 100% of that variety. However, the earlier blocks, including Calanais kerb cairn, Gob Eirer and the primary block at Dun Bharabhat, contain significant proportions of naked grain in their assemblages, with 20% of the barley at Calanais kerb cairn of the naked variety. This indicates that a limited quantity of naked barley was still being grown in the region from the early second to mid first millennia BC. The cultivation of this variety was still economically viable during the second millennium BC due to the relatively warm climate (see Section 2.4) but its cultivation became increasingly more risky in the first millennium BC due to the worsening climate. This resulted in the almost exclusive presence of hulled barley from the Iron Age onwards, with only the occasional naked grain being identified. The apparent proportional increase in naked barley grain in the Late Iron Age block at Galson seen in Figure 7.3 should be viewed with caution due to the small number of grains the proportions are based upon (n=15).

However, the impression of the overwhelming dominance of hulled barley may be slightly over-estimating the variety's significance because of the role of crop-processing in preserving material in the archaeological record. The process of 'graddening' outlined above usually involved an additional drying stage before the gentle grinding to remove the hulled material. The drying was usually undertaken within the immediate vicinity of the domestic hearth and so would greatly the increase the potential for crop-processing accidents for hulled grain compared to naked grain. The natural place for the burnt grain to be thrown in disgust would be the domestic hearth, the key area for carbonisation and subsequent archaeological preservation as envisaged in the taphonomic model outlined in Chapter 5. Hence, hulled barley would be over-represented in the archaeological record. That said, it is still probable that the large majority of the barley crop from the late first millennium BC was of the hulled variety as indicated by the extremely high proportions of the total block assemblages.

The occasional naked grains could stem from very small-scale experiments in cultivation or represent what is in effect weed contaminants of a few naked plants in the hulled crop. It may also represent a phenomenon noted by Hillman (quoted in Holden & Boardman, 1998), by which a small proportion of hulled grain did not fuse to the enclosing lemmas and paleas when the growing season had been shortened by early frost, drought or excessive rain. This resulted in a small proportion of the grain from the hulled crop resembling the naked variety. The increased presence of naked grain in the latter half of the first millennium AD (Figure 7.4) is therefore intriguing. Again, the actual proportions in terms of the identifiable barley recovered are very small but the more widespread presence of the variety across the sites must be explained. It may represent an increased frequency in experimentation, perhaps as a result of perceived use of the variety elsewhere in the Atlantic continuum. Also, it may result from an increase in the trade and exchange of grain across Atlantic Scotland, directly as naked grain or indirectly as weed contaminants of seed from other areas where naked barley cultivation was still practised. One such area was Orkney, judging by identifications from the Mid to Late Iron Age phases at the Howe (Dickson, 1994). Finally, it may reflect subtle changes in the length of growing season within the region, with the increased frequency of occasional grains stemming from the less predictable climate of the mid to late first millennium AD (see Section 2.4).

There are two main species of barley that were cultivated in prehistoric Scotland (Boyd, 1988; Dickson & Dickson, 2000), two-row (*Hordeum distichon* L.) and six-row (*Hordeum vulgare* L.). In two-row barley only symmetric grain is grown in the medial spikelet and no grains grow in the two sterile lateral spikelets. In six-row barley the ratio of symmetric:asymmetric grain should be 1:2 as one symmetric grain grows within the medial spikelet and two asymmetric grains grow in the two lateral spikelets coupled with each rachis internode and medial spikelet (Renfrew, 1973: Zohary & Hopf, 1994). Figure 7.5 presents the ratio of symmetric:asymmetric grain for hulled barley from each block with at least 10 symmetric and asymmetric hulled barley grains. If six-row barley was the only species present on the sites, the asymmetric ratio value should be approximately two. However, it can be seen in Figure 7.5 that though some of the blocks display asymmetric values near to or over two, such as

CC, **CN-W** and **LB-LIA**, others have values ranging from 1.8 down to almost 1.2. Some of these blocks, such as those from Bostadh, had substantial numbers of symmetric and asymmetric grains on which the ratios were based, so the values suggest a significant two-row component to many of the block assemblages.

Figure 7.6 presents the projected proportions of six-row and two-row hulled barley from blocks with at least 10 symmetric and asymmetric grains. The projected proportions are based on the ratios displayed in Figure 7.5. Any value over 2 was taken as representing 100% six-row barley and the proportion of six-row barley for values below 2 estimated by the following equation. The calculation is based on the assumption that the six-row species is represented by one symmetric grain coupled with two asymmetric grains and any symmetric grains remaining from this grouping represented the two-row component.

Proportion of six-row hulled barley = (asymmetric value from asym:sym ratio*100)/2

Figure 7.6 indicates that most blocks had some two-row cultivation in the arable economy and in some cases, such as **GE**, **DB-S** and **AD-IA**, this component was over 30% of the hulled barley.

A key deposit in assessing the contribution of two-row barley was the bulk sample of probable thatch from the conflagration of the secondary structure at Dun Bharabhat (Context 169). The excellent preservation of the cereal remains meant that the symmetric and asymmetric hulled barley grains were easily identified allowing increased confidence in the interpretative value of the resulting ratio. More importantly, the charring conditions meant that many rachis internodes and even some sterile lateral spikelets were preserved. Significant quantities of six-row and two-row barley rachis internodes were recovered, the key cereal parts for the differentiation of the two species.

Some other blocks also contained both two-row and six-row rachis internodes and from these it was possible to calculate another estimate of the proportion of barley species in the crop assemblage. Figure 7.7 presents both the projected proportions calculated from the rachises and the ratio of symmetric:asymmetric hulled grain from blocks with at least 10 grains and rachises. Both estimates demonstrate the same trend with the highest proportion from **DB-S** (37-27%), a decrease to lower proportions in the two blocks from Loch na Beirgh and **BO-LIA**, before a slight increase to between 14-20% during **GAL-N**. The slight discrepancy between the rachis and grain estimates is probably due to the differential survival of the slightly larger and more robust six-row rachises. However, the consistent pattern displayed by both estimates suggests that the pattern is real and two-row barley was a significant albeit small component in the crop assemblage.

So rather than invoking a barley monoculture of six-row hulled barley, detailed analysis of large assemblages has indicated that the hulled and naked varieties and the two-row and six-row species were grown in the wider economic landscape at various points and proportions throughout the first millennia. Naked barley seems to have been grown in significant quantities only in the early to mid first millennium BC before being phased out by the almost exclusive use of hulled barley. Six-row barley seems to be the dominant species but two-row was also grown in its own right. It is perhaps important to note that the highest proportion of two-row barley in the block assemblages came from the straw rich layer in the conflagration at Dun Bharabhat. Perhaps the species was specifically cultivated for straw production rather than just grain production, for use as thatch and internal furnishings or as fodder. This hints at a relatively sophisticated regime of cultivation within the landscape, with certain barley varieties and species grown for specific purposes.

The cultivation of oat

Figures 7.1 and 7.2 highlight the appearance of significant amounts of oat in the later first millennium AD. Prior to this, the recovery of the occasional oat grain is likely to stem from weed contamination of the barley crop or from the incorporation of grassy material into the domestic hearth. It is possible that the proportionally high quantity of oat at Guinnerso may represent very small-scale cultivation of oat within the immediate marginal landscape around the site. However, only 61 cereal grains were recovered from the entire block so caution must be exercised when assessing possible cultivation practices from the site.

The identification of oat to species cannot be based on grain morphology and can only be differentiated through analysis of the floret bases. These are extremely fragile and only rarely survive the carbonisation process (Boardman & Jones, 1990), especially with the charring conditions within domestic hearths burning peat. However, a few floret bases have been recovered and these are totalled by block in Table 6.4. All of the floret bases belong to the cultivated species (*Avena sativa* L.), with two being recovered from blocks **LB-C**, **BO-LIA** and **BO-LIA/N** and only one from **BO-N** and **GAL-N/M**. All of these blocks have significant numbers of grain, except for **LB-C** where the floret bases and the occasional oat grain presumably represent a weed contaminant of the barley crop.

It is possible that there are two stages to the uptake of oat. The initial cultivation may be represented in the blocks **LB-LIA**, **BO-LIA** and **BO-LIA/N**, with each displaying Ubiquity scores between 40-50% and proportions of the total assemblage of between 1-5%. The second stage represents an increase in the quantities of oat in the Norse blocks of **BO-N** and **GAL-N/M**, with Ubiquity scores of 72-80% and proportions of the total assemblage of between 19-27%. This two-stage uptake may indicate an initial experimentation with oat during the Late Iron Age period followed by a more substantial and important contribution to the arable economy in the Norse period. The initial uptake may represent a need or desire for the diversification of the arable economy. It also expands the area of land that can be brought under cultivation, as oat can be grown within much more marginal areas than barley. Also, oat needs little tending of the crop during the growing season unlike barley that requires labour intensive cultivation practices, such as manuring, to maintain yields (Bond *et al.*, forth. a & b). The uptake of oat therefore involves an extensification of the arable economy into more marginal lands, a concept explored in more detail with reference to other sites in the Western Isles and Atlantic Scotland in Section 8.2.

The marked increase in the amount of oat recovered in the Norse blocks may also reflect a fundamental change in the subsistence economy that occurred in the 9th century cal AD. This was also accompanied by other significant changes, such as the dramatic increase in the quantities of herring recovered from the Norse midden at Bostadh (Ceron-Carrasco, forth.). Firstly, it implies that more marginal land was under cultivation during the Norse period that requires a more extensive system of land control by the various homesteads. The marginal land is more likely to be within the hinterland of the sphere of influence of the homestead and so cultivation of this land could imply greater levels of co-operation or even communality between the various communities. It also may represent the beginnings of the infield/outfield system readily identifiable in the later Medieval and post-Medieval periods (cf. Dodghson, 1993).

Secondly, this fundamental shift in the subsistence base may reflect a wider social re-organisation that accompanies the influx of the Norse across the Hebrides. Two basic schools of thought exist to describe the impact of the Norse; one involves essentially an invasion and subjugation of the native population (cf. Crawford, 1981) whilst the other invokes a less violent and more co-operative integration of native and Norse (cf. Ritchie, 1993). This shift in the subsistence base could be used to argue for both cases. On one hand it may reflect the more mixed arable and fishing practices of the invaders who either displaced or killed the native population or on the other hand reflect a change in the subsistence base through the exchange of ideas and specialist expertise between the two groups. On balance, it is the author's view that the palaeoeconomic evidence, coupled with the fundamental switch from circular to rectilinear structures (*contra* Sharples & Parker-Pearson, 1999) and discussion of the place name evidence (Kruse, 2002), hint at a more interventionist Norse invasion. However, it is beyond the scope of this study to discuss this point in depth.

The cultivation of flax

Various quantities of flax seeds were recovered from **AD-IA**, all the blocks from Loch na Beirgh and Bostadh and **GAL-N/M**. This indicates an expansion into flax cultivation in the latter part of the first millennium AD. However, the various quantities, in terms of both the overall percentage of the block and the Ubiquity score, did not increase progressively over time like the figures for oat grain, indicating variable uptake of the crop from site to site. Flax seeds have been identified from across Atlantic Scotland (Dickson & Dickson, 2000), usually appearing in significant quantities in the Norse period (though see Section 8.2).

Flax is cultivated for two primary products, the oil from the seed and the fibre from the stem that can be processed for cloth. Possible secondary products include the remains of the seed pressed for oil (linseed cake) and the remaining stems following fibre processing, both of which could be used as fodder or fuel. All the products can be obtained from the same plant, though loss in oil production and deterioration in the quality of the fibre ensues. Processing of the crop involves uprooting to maximise the length of stem and then removal of the seed heads (bolls) for drying and storage. The oil is then extracted when needed through grinding in saddle querns or smaller mortars. Processing of the fibres requires a number of stages, summarised in Table 7.2. The processing from plant to fibre could take several months and even years and required an investment of labour and planning that had to be offset from the economic returns from the cloth (summarised from Bond & Hunter, 1987).

Table 7.2 also outlines the archaeological material that remains from the processing of both the seed and the fibre. In theory, the presence of these archaeological remains should allow the identification of the processing within the wider economic landscape of the site. However, in practice the remains are very few in number, are generally equivocal in interpretation and could be used for other activities. For example, saddle querns, pestles and grinding stones have been found from the extensive excavations at both Loch na Beirgh and Bostadh but these could also have been used for other plant processing, principally other crops. Also, the structural evidence for the management of the streams and ponds needed for the retting of the fibres would be very hard to distinguish from later water-management features, the construction of which may have destroyed the remains in question. Finally, the relatively sophisticated equipment needed for the hackling, spinning and weaving of the fibre would have comprised a series of inter-connected artefacts. These would be very hard to identify from the archaeological record, because of the generally poor survival of organic material. Also, the artefacts that do survive, such as those made of bone within machair sites, may be difficult to associate with the specific tasks of flax processing.

Obviously the presence of carbonised seeds strongly suggest the processing and possible cultivation of flax but again it is very difficult to distinguish between the processing for seed and fibre. It has been argued that flax seeds are more likely to be carbonised during accidents in the drying process of the bolls for oil than at any stage in the processing of the fibre (van Zeist, 1970; Bond & Hunter, 1987). Also, Dickson (1983c) suggested that carbonised flax seeds pressed together may represent the remains following oil extraction, though this may be a function of the carbonisation process of oil rich seeds. This results in a bias in the carbonised material in favour of seed processing (van Zeist & Palfenier-Vegter 1979). However, if the waste material from both processes was used as fodder or fuel it could eventually be incorporated into the domestic hearths, carbonised and then spread across the site. In this way, seeds from both processes would be recovered.

Only four of the samples (three from **BO-LIA** and one from **LB-LIA**) had greater than 20 flax seeds (see Appendix B). The four samples also contained large quantities of burnt grain (largely barley with a little oat) and so therefore may reflect accidents in the drying processes of the various crops. The seeds from these samples probably stem from processing for oil. The other samples with less than 20 seeds usually had variable proportions of other plant parts and species and so the seeds from these samples may have derived from the carbonisation of both seed and fibre residues in the domestic hearths. It has been suggested that the size of the seeds vary in modern varieties depending on whether the crop is grown for oil or fibre, with the seeds bigger for oil production. Bond & Hunter (1987) indicated that seed from five later prehistoric and Norse sites were smaller than modern varieties grown specifically for oil, even allowing for shrinkage during carbonisation. The length and breadth of the seeds from this study were measured for all of the samples (up to 50 for the two samples with greater than 50 seeds). Table 7.3 presents a summary of the results. Little differentiation in size across all of the blocks of analysis was noted, apart from those blocks with very few seeds that were skewed from the average. The averages and range of dimensions were also in keeping with those recorded for flax seeds elsewhere in Atlantic Scotland during the prehistoric and Norse periods (Bond & Hunter, 1987). Therefore it is proposed either that flax was grown only for the production of linen or that both products were produced and taken from the same crop. Alternatively, the carbonisation bias highlighted by van Zeist & Palfenier-Vegter (1979) means the large majority of the identified seeds stem from flax from oil processing. Further research through phytolith analysis of the ground stone tools and detailed SEM work on possible flax tubers or rhizomes may clarify the problem but on the present evidence it seems most likely that both primary products were taken from the same crop and flax variety.

A final point concerning flax is its possible association with social stratification. The cultivation and processing of both primary products, especially the fibre for cloth, requires access to labour, economic reserves to sustain the settlement through the processing, special equipment and the necessary skills to undertake the final spinning and cloth making if these were undertaken on the site. Also, the inhabitants would need to have access to specialised trade networks if the processed fibres or cloth were to be traded or exchanged. It is possible that those settlements undertaking flax cultivation were of a higher social standing than the norm, perhaps reflected by the non-linear uptake of the crop across the later blocks in this study. Therefore, the presence of significant quantities of flax during the three main blocks at Bostadh may hint at continued social standing of the inhabitants of the site, despite major changes in the structural configuration and probable social upheaval with the Norse incursions. Also, the single seed of flax from An Dunan came from an ash spread immediately associated with the ornamental hearth, perhaps reinforcing the perceived social importance of the plant through its incorporation into the funerary activities undertaken on the site.

The presence of wheat and rye

Both wheat and rye were recovered in very low numbers and are likely to represent weeds of cultivation rather than cultivation in their own right. Occasional grains of wheat were identified from **CC**, **LB-C** & **LIA**, **GAL-N/M** and all the blocks from Bostadh. Further identification to species level was not undertaken due to the overlap of species differentiation possible from grain morphology alone (Jones, 1998), their low numbers and their probable derivation as weeds from the barley and perhaps oat crop. Only a few rye grains were recovered from **BO-LIA** & **N** and **GAL-N/M**. The Ubiquity increase of wheat and rye towards the end of the first millennium AD may indicate a slight alteration of the weed ecology. It is interesting to note that of the three blocks containing rye, two were Norse. Perhaps this reflected increased exchange of agricultural products, such as cereal seed, across Atlantic Scotland that would introduce slightly different weeds to the island.

7.2.3 "Where were the crops grown?"

Hillman (1981) outlined the identification of the position in the landscape for arable agriculture through the habitat preferences of the weed seeds associated with crop-processing waste and sometimes cleaned grain. The application of this concept has been successfully applied in a number of areas across Britain (Greig, 1991) including Southern Britain (cf. Jones 1985, 1996) and North East England (cf. van der Veen, 1992). In theory, the Western Isles should be an excellent area for attempting this type of analysis as there are a number of mutually exclusive landscape zones with very different soil conditions and therefore weed ecologies. Three basic landscape zones would have existed where arable agriculture could have been undertaken in the past including the machair, the improved ground ('the brownland') and more marginal land of peaty rankers on the fringe of the blanket bog or 'blacklands' (see Sections 2.2 & 2.3 for more detailed descriptions). However, the fundamental assumption behind this form of analysis is that the wild components from the carbonised assemblage stem largely from the weed contaminants of the crop in question. The taphonomic arguments outlined in Chapter 5 have demonstrated that this assumption cannot be accepted and this view is reinforced by the mix of species from a variety habitats for the majority of the samples in this study (see Appendix B).

However, certain atypical deposits may allow insights into the zone of cultivation. For example, the sample of burnt straw or possible thatch from the conflagration at Dun Bharabhat (C.169) had a number of wild components with ecological preferences indicative of arable agriculture. The assumption of association between wild components and weed contamination is tenable for the *in situ* burning of the straw layer due to the lack of mixing with plant material from other human behavioural episodes of discard. Heather furnishings, such as rope or twine, can explain the limited presence of heathland taxa. The remaining taxa are all common weeds of cultivation and dry grassland. The presence of Chickweed (*Stellaria media* L. Vill.) indicates relatively nitrogenous soil conditions (Sobey, 1981). This may represent field rotation between pastoral and arable agriculture, on a seasonal or spatial basis, or the deliberate incorporation of dung into the soil as a fertiliser and stabiliser. Several of the species, including Ray's knotgrass (*Polygonum* cf. *oxyspermum* M & B ex Lb), Bulbous buttercup (*Ranunculus bulbosus* L.) and Wild turnip (*Brassica rapa* L.) have strong associations with machair grassland (Pankhurst & Mullin, 1994). Figure 4.4 presents a pollen profile taken from the loch deposits from Loch na Beirgh, dating to the first millennia BC and AD. The pollen source areas for the diagrams are extra-local and essentially reflect the dynamics of the machair and the fringing 'brownland'. Lomax (1997) noted the presence of barley-type pollen and the unusually high quantities of Brassicaceae pollen associated with other plants of cultivation, such as Ribwort plantain (*Plantago lanceolata* L.).

The evidence from the burnt straw layer, coupled with this pollen sequence, points to the cultivation of the crop occurring largely within the machair grassland and the fringing 'brownland' behind Traigh na Beirgh (see Figure 4.2). A marked correlation between the presence of significant quantities of grain and Wild turnip seeds was also noted from many of the samples from all of the blocks from the three Bhaltos sites, including Dun Bharabhat, Loch na Beirgh and Cnip (see Appendix B). This correlation of the main weed contaminant may be indicative of the barley crop being grown in the machair and fringing 'brownland'. If this is the case, then the core area of barley cultivation of the Mid to Late Iron Age in this part of the Bhaltos peninsula remained the same for approximately a thousand years, representing a remarkable stability of land use and tenure.

Assessing the likely landscape zone for cultivation for the other sites is difficult. It is unlikely that the wild components from An Dunan and Guinnerso stemmed from weed contaminants of arable cultivation. Also, the burning of peaty turves at Calanais kerb cairn, mixed the weed contaminants of the barley with the plant contamination from the fuel. The only sample from Galson that had significant numbers of grain and wild components was Sample 2. A mix of habitats was represented by the wild components with dry free-draining soils indicated by Wild turnip, Curled dock (*Rumex crispus* L.) and Corn spurrey (*Spergula arvensis* L.) through to moorland taxa, including heather (*Erica*/*Calluna* spp.) and sedges (*Carex* spp.). This may reflect the various areas where the crops were grown, as barley, oat and a little flax were recovered from the sample. For example, the barley could have been grown on the machair or 'brownland', the oat in the more marginal heath and the flax within the machair (see below). The same sort of mixing occurred in the grain and wild component rich samples from Bostadh. However, only a few of these samples had a mix of barley and oat that could theoretically mix the weed contaminants from the better and more marginal agricultural land. Therefore, the unquantifiable mixing of plant material being incorporated into the domestic hearths is as likely to explain the variable habitats of the wild components as the mixing of weed ecologies from different crops.

Despite this uncertainty, there seemed to be a positive correlation between the presence of flax and Corn spurrey. Figures 7.8 & 7.9 demonstrate this correlation through percentage of each plant class and Ubiquity counts from each site block with at least ten samples. The site blocks with significant quantities of flax such as **BO-LIA** also had significant quantities of Corn spurrey above the usual levels recovered from sites with little or no flax present. Table 7.4 presents the Ubiquity counts for samples with flax and Corn spurrey. Many of the samples from the blocks that had both flax and Corn spurrey usually had both species in the same deposits, highlighting the weed association.

Jessen & Helbaek (1944) first noticed this association and suggested it might be specific to flax fields. However, Bond (1994) noted that Corn spurrey was a common weed of barley and oat crops in the first millennia BC and AD in the Northern Isles. This seems to be at odds with the evidence from this study that indicates many of the seeds of Corn spurrey were found in carbonised assemblages that contain flax. It is proposed that this positive correlation is indicative of flax cultivation within the machair, where Corn spurrey would flourish in the light free-draining shell sand (New, 1961). Machair would be ideal for the easy harvesting of the flax as uprooting is easier within the light soils, a harvesting strategy that maximises the stem and therefore the fibre yield. However, flax quickly depletes the nutrients within light soils and so soil amendment would be required for sustained use of the machair. Hints of amendment strategies involving the input of dung or seaweed from block **BO-LIA** were provided by the correlation of Chickweed with the flax and Corn spurrey (Table 7.4). Indeed, Chickweed was relatively common in most of the site blocks (Figure 7.10), suggesting amendment of soil through the input of dung or pastoral rotation with the arable land was commonplace.

7.2.4 "How were the crops processed?"

Again, there are a number of problems in answering this question due to the taphonomy of the archaeobotanical assemblages. The first major problem is the mixing of different plant elements and species prior to carbonisation. This could not only mix plant elements from different crop-processing stages but also from different behavioural episodes unrelated to the arable economy. The second problem is the very poor conditions of preservation for carbonised remains in most domestic hearths that used well-humified peat as their main fuel (see Section 5.8.3). Approximate thermal histories of the peat ash from the experimental hearths were estimated through comparing the heating and cooling curves in the high temperature susceptibility measurements. This demonstrated that most of the archaeological ash was heated to over 700 °C. This would totally destroy or severely degrade most plant material, including most types of cereal chaff (Wilson, 1984; Boardman & Jones, 1990). The generic composition of most of the samples and the block assemblages reflects this poor preservation with high proportions of degraded grain and the hardier plant elements, such as the culm bases and rhizomes. The final problem is the limited range of crop-processing stages that are likely to be represented by the archaeobotanical evidence. For example, most of the material was carbonised in the hearths in the interiors of the domestic structures and much of the crop-processing is likely to have been undertaken away from these points. However, the final stages of processing hulled barley involve drying, usually through singeing of the ears and gentle grinding to remove the hulled material. This process was called 'graddening' in the recent past in the Northern Isles and was usually undertaken around the domestic hearths when the grain was needed (Fenton, 1982). Hence, the high number of grain-rich samples usually derived from accidents in these final processing stages.

Despite these problems, there are a number of points of interest relating to the earlier crop-processing stages. The first point involves the way in which the crops were grown. Many of the grain-rich samples contained a mix of barley species and varieties and oat and flax in the later periods as well. This may reflect mixing of different crop products and processing residues prior to or during carbonisation or may reflect the approximate composition of the plants grown in the field. Though it is probable that flax was grown independently to maximise the yield of this difficult crop, the other crops could have been grown together. The key advantage of crop mixtures is their ecological and climatic flexibility (M Jones, 1996). A mix of barley varieties, species and perhaps the addition of oat, could produce a crop essentially anywhere in the landscape, apart from the 'blacklands'. This mix would also produce a crop under most of the range of Hebridean climatic conditions as well.

However, to assess the presence and frequency of this mixing, demonstrable storage deposits are needed or other rarely discovered accidents in preservation (*ibid*). Storage deposits in Atlantic Scotland are very difficult to identify as there is no structural or artefactual material that can be immediately recognised as being used for grain storage. Therefore, none of the samples from this study have been definitely identified as storage products. However, the conflagration deposit at Dun Bharabhat again allows more detailed interpretative insight. It has been argued above that this deposit stems from a coherent crop with little mixing of other plant material. The mix of six and two-row hulled barley therefore probably represents a crop mixture, with the overall proportions of the two barley species in the crop dependent on the local and seasonal conditions.

The deposit is also important as it stems from an early crop-processing stage involving the removal of the straw from the ear, probably during the threshing/raking. This is confirmed by the ratio between the culm bases and the basal rachises (4.6:1), which shows that most of the ears were separated from the straw prior to its use as thatch. Hence, we can estimate approximately 80% efficiency for the separation of the ear from the straw during early crop-processing. Also, over 1200 cereal culm bases were recovered from this layer, indicating that the crop was harvested by uprooting (Hillman, 1981). It has been proposed from the associated weed ecology that the crop was likely to have been grown on or on the fringes of the machair of Traigh na Beirgh and uprooting would have been the easiest harvesting method in the light machair soil. It is interesting to note that many of the samples from all of the blocks from Dun Bharabhat, Cnip and Loch na Beirgh had significant numbers of larger culm bases (>2 mm) indicating the repeated use of uprooting as the primary harvesting technique. Though uprooting maximises the straw length and therefore yield, it is also destabilising for the soil, an important consideration in the fragile and easily eroded machair. It is therefore interesting to note that throughout the millennium of occupation at Loch na Beirgh, the occupants were constantly raising the level of the foundations due to the rising loch level. The loch level was rising due largely to the influx and migration of the eroding machair sand into the loch, confirmed by the sediment sequence of the core transects and pollen profiles taken by Lomax (1997). It is proposed that a major contributor to this geomorphic instability was the intensive agricultural practices concentrated on the machair throughout the first millennia.

Figure 7.10 presents the Ubiquity scores for larger culm bases (>2 mm) from each site with at least 10 samples. Nearly all of the blocks ranged from 50 to 90 % Ubiquity and again this may indicate the repeated use of uprooting as the primary harvesting technique. Again this would maximise the straw yield but also create soil instability during harvesting, especially within the machair. Therefore, a number of soil amendment strategies may have been employed to offset this problem. Figure 7.10

shows the Ubiquity scores for Chickweed from each site with at least 10 samples. The association of Chickweed as a weed of the barley crop was also noted from the evidence of the sites on the Bhaltos peninsula. Therefore, it is proposed that the deliberate input of dung and seaweed, perhaps coupled with pastoral rotation was routinely undertaken to improve the soil. This amendment would increase fertility and therefore yields, as well as increasing organic content, leading to improved soil coherency and decreasing the erodibility of the soil (Summerfield 1991, 177).

7.2.5 "What were the crops used for?"

Table 7.5 outlines the various products and secondary products from the crops and their possible uses. However, confirming many of these specific uses is difficult due to the mixed taphonomy of the assemblages and the lack of evidence of many of the secondary products. For example, it is assumed that a significant proportion of grain was ground to create flour for bread. The grain and the querns are ubiquitous on Atlantic Scottish domestic sites but the secondary product, i.e. the bread, is extremely rare. This is a function of both identification (the bread could be classified under 'burnt amorphous material') and preservation (baking and cooking accidents would be the only times when bread could routinely be preserved). Also, the form that the bread took is unknown and so its recognition is greatly complicated. Finally, very few structures have been identified as possible ovens in Atlantic Scotland and those that have, at Howe in Orkney for example (Ballin-Smith, 1994), could have been used for pottery manufacture. However, barley bran was discovered in human coprolites of Mid Iron Age date at Warebeth broch in Orkney (Bell & Dickson, 1989), demonstrating human consumption of barley, perhaps in the form of a broth. Another way to test for the presence of barley secondary products would be through the detailed chemical analysis of food residues in pottery (cf. Craig *et al.*, 2000). Identification of ale production in prehistoric Britain has usually relied on the recovery of malted barley (cf. Jessen & Helbaek, 1944; Greig, 1991) but the level of grain preservation in this study and Atlantic Scotland in general precludes such an identification. Despite these problems, it is likely that the harvested crop was used for the production of straw, principally for furnishings, fodder and basket manufacture, as well as the production of grain principally for human consumption, in the form of broth, bread and perhaps ale.

7.3 Wood and timber procurement

7.3.1 General

This section highlights the recurring features across the different blocks regarding wood and timber procurement and use. Certain aspects of the analysis are based on the grouping of the charcoal of shrubs and trees into broader groups including deciduous roundwood, deciduous timber, coniferous roundwood, coniferous timber and indeterminate fragments. Heather has been included within the deciduous roundwood category to distinguish the heather fragments from conifer tree roundwood. Essentially, most of the deciduous material and the coniferous roundwood is likely to be locally derived whereas a substantial proportion of the coniferous timber is made up of exotic conifers, representing collected driftwood from North America (cf. Dickson, 1992). Figure 7.11 presents the general composition of the total charcoal fragments from each block using these groups. All of the quantitative analyses that follow are based on fragment counts rather than weight. Almost all of the blocks had a relatively similar composition, with significant amounts of deciduous roundwood and indeterminate fragments, variable amounts of deciduous and coniferous timber and usually very little or no coniferous roundwood. The only site assemblages substantially different to this pattern were the hand-retrieved samples of largely coniferous timber from **DB-S** and the block total of mostly coniferous roundwood from **CN-W**. The latter block total was based on only three samples of 35 fragment identifications, with one of the samples containing most of the fragments, presumably from the discard of ash from a single burning episode. Therefore, only limited inference can be made from this relatively small assemblage. The three main areas of discussion in this section focus on the taphonomy of the charcoal and the interpretative value from the roundwood and timber fragments. Analysis of the heather charcoal is undertaken in the context of moorland exploitation in the following Section 7.4.

7.3.2 Taphonomy

The basic taphonomic model outlined in Chapter 5 can also account for the carbonisation and spread of charcoal on the sites sampled. Mineral magnetic analysis has indicated that wood was probably not used as the principal fuel. This explains the relative lack of charcoal on most of the sites, one of the key points for the assemblage as a whole. Indeed, when compared to assemblages in lowland Scotland where wood was used as the main fuel, the charcoal concentrations are very low. Therefore, the remains represent the relatively small-scale incorporation of wood into the hearth either a) deliberately, as kindling or sporadic fuel, or b) accidentally, as part of another fuel source or the discarded residue of human behaviour undertaken near the fire, such as wood-working. Only the conflagration level in **DB-S** has substantial quantities and weight of charcoal as it represents *in situ* carbonisation of wood remains.

This generic model is supported by the ring counts for the different classes of charcoal. Figures 7.12 to 7.14 present the ring counts for deciduous roundwood (pith to bark) from the Early Iron Age through to Late Iron Age I periods. All of these periods show similar ring profiles, a common pattern for each of the classes of the charcoal material. Therefore for this analysis, the ring count profiles for each charcoal class have been grouped into one generic assemblage from all of the blocks. Figure 7.15 and Table 7.6 present all of the ring counts for deciduous roundwood excluding the heather fragments (n=109), with an age range from 1 to 15 years. Figure 7.16 and Table 7.7 present the ring counts for coniferous roundwood (pith to bark) from all blocks (n=8), with an age range of 3 to 18 years. These profiles confirm that all of the fragments from these classes come from short-lived parts of the shrubs / trees, reflecting the use of small twigs for kindling or the accidental incorporation into the fire of small quantities of roundwood from the well-humified peat (see Section 5.7.3) and trimmings from branchwood.

Figure 7.17 and Table 7.8 present the ring counts for deciduous timber from all the blocks (n=101), with an age range from 1 to 16 years. Figure 7.18 and Table 7.9 present the ring counts for coniferous timber from all the blocks except for **DB-S** (n=204), with an age range from 1 to 20+. In both classes, over 60% of the fragments have ring counts of 6 or less. This low count firstly reflects the way that timber burns in a fire, judging by the low counts from the timber logs burnt in the experimental hearths (see Section 5.7.3). Also, the small ring counts may reflect the way that charcoal fragments post-deposition and during excavation, storage and analysis. For example, Figure 6.1 and 6.2 show the fragmentation that occurred for the hand-retrieved timbers taken from **DB-S**. These were relatively coherent within the soil but fragmented greatly on excavation and during storage. Finally, the low count may reflect the incorporation of wood chippings from timber working casually discarded into the fire or utilised as kindling. Chippings with low ring counts were found from waterlogged levels at Dun Vulan from the wood working of substantial driftwood coniferous timber (Taylor, 1999 and pers. comm.).

7.3.3 Roundwood

No chronological or spatial patterns were discernible in the data set, as most blocks varied in composition to some extent. Birch (Figure 7.19) and Ling heather (Figure 7.20) were the most numerous deciduous roundwood species consistently recovered from the site blocks (see Table 6.7 and Appendix B for block and sample counts respectively). Significant quantities of willow and hazel were also recovered from many of the blocks, with some Pomoideae undifferentiated and a few fragments of alder and *Prunus* sp. The single fragment of Purging buckthorn from An Dunan represented the only species exotic to the island. Most of the roundwood fragments from each block (except for Cnip) were deciduous and the only coniferous roundwood recovered were Pine and Juniper, with the Juniper likely to have been collected from the surrounding moorland at Guinnerso. All of the rest of the species are found in inaccessible places in modern day Lewis (Pankhurst & Mullin, 1994) and have also registered in a number of the contemporary pollen spectrums from across the Western Isles (see Section 2.5). It is likely that the fragments recovered relate to isolated stands of trees and shrubs in the landscape. These may have had an element of human control / management or may have been inaccessible, like those naturally occurring today.

7.3.4 Timber

No chronological or spatial patterns were discernible in the data set, as most blocks varied in composition to some extent. In general, most of the blocks with significant quantities of charcoal fragments had at least 20% timber. Figure 7.21 presents the proportions of deciduous and coniferous timber for blocks with at least 10 timber fragments. In general, this indicates that conifer made up at least 50% of the timber assemblage from most blocks (apart from Cnip), with deciduous timber less numerous. Again, the most common deciduous timber was birch, with some oak, willow, alder, hazel and a few fragments of ash and Pomoideae undifferentiated. Nearly all of these genera could have been locally derived from isolated stands of trees and shrubs in the landscape. These may have had an element of human control / management in sheltered valleys or may have been inaccessible areas such as cliffs, like those trees and shrubs naturally occurring today (Pankhurst & Mullin, 1994). Cursory examination of a fragment of uncarbonised wattle from the waterlogged upper levels of the secondary roundhouse phase at Loch an Beirgh (**LB-R**), indicated that hazel was being used and perhaps coppiced, judging by the possible coppiced heel at the end of one of the withies. Therefore, limited woodland management seems to have been undertaken for internal structural furnishings in the first half of the first millennium AD.

Two of the deciduous genera, oak and ash, are more doubtfully native. A single fragment of ash and four fragments of oak was recovered from Gob Eirer, with further oak identifications made from **AD-IA**, **CN-R** and **GAL-LIA**. The 45 fragments of oak from **CN-R** come from one sample and so probably represent the discard of ash from a single burning episode. Do these fragments represent collected driftwood from the mainland / North Atlantic or perhaps hint at some form of timber trade with the mainland? The evidence is very slight so firm conclusions are impossible. Also, in the case of Gob Eirer certain pollen diagrams are still registering small concentrations of oak pollen at the beginning of the first millennium BC, so the oak and perhaps ash from that site may be from final vestiges of local mixed woodland.

Again, the conflagration level in Dun Bharabhat provides very important interpretative insights. The hand retrieved samples were exclusively of pine and spruce timber from burnt structural remains, linking the type of timber to their use in the superstructure of a Mid Iron Age building. It has been argued in Section 6.3.5 that the spruce was collected as driftwood since the genus was exotic to Britain during the Iron Age and shipworm boreholes had been identified. The pine could have come from a locally managed source given the evidence from loch sediments of small quantities of contemporary pine pollen and the recovery of pine roundwood and bark fragments. These roundwood fragments are more likely to come from a local source than driftwood as timber locked in the North Atlantic system for a couple of years is usually denuded of all roundwood and bark apart from larger branches.

This pattern is repeated across the blocks with the only coniferous roundwood being pine. Also, the other coniferous genera were all exotic to the British Isles during the first millennia including fir, Douglas fir, spruce and larch. Some of these remains also had boreholes, confirming their driftwood status. However, the most common coniferous genus was pine. Figure 7.22 presents the pine timber as a proportion of the total assemblage for blocks with at least 10 charcoal fragments. This could represent a local resource, supported by the presence of pine roundwood fragments on some of these sites, and/or driftwood, as some of the pine timber also had boreholes. The ring counts from the coniferous timber from Dun Bharabhat (Figures 6.1 and 6.2) and the blocks as a whole (Figure 7.18) show that though most of the fragments were very small, some had greater than 20 rings. Conversely, none of the deciduous timber had greater than 16 rings (Figure 7.17). Though this may be a function of fragmentation of the deciduous timber, it may also indicate that the larger pieces of timber were confined to the conifers from the locally managed source or driftwood.

It is therefore proposed that the wood and timber supply for most of the sites seems to stem from two main sources. Locally derived deciduous roundwood and branchwood was used for internal furnishings and other uses, such as basket weaving. Timber was taken from locally derived pine and from driftwood of pine and various exotic genera. Also, there are slight hints at mainland derived material from the occasional recovery of oak and ash fragments, though this is at best tentative. However, the site types from which the evidence stems do not include the monumental Atlantic roundhouses of the Mid Iron Age. Indeed, many of the structural configurations imply a move to conserve timber for roofing, for example the wheelhouse and cellular architecture (cf. Armit 1992, 1996). Whether the Mid Iron Age Atlantic roundhouse *floruit* required a trade in timber (cf. Fojut, forth.) or was based on a mix of driftwood and locally derived wood is hard to resolve from present knowledge. However, the conflagration from Dun Bharabhat of the secondary roundhouse only slightly smaller than the original Atlantic roundhouse dates within the broad period of the Mid Iron Age and so may hint at local procurement for the smaller monumental structures. What is needed is directly associated structural evidence from a substantial Atlantic roundhouse and the likely presence of *in situ* timbers from the primary and secondary roundhouses at Loch na Beirgh represents a unique opportunity to address this important issue.

7.4 Wild plant gathering

7.4.1 General

The third main interpretative research theme assesses the contribution of gathered plants to the economy of the first millennia. Three main zones within the landscape are discussed including the moorland, seashore and woodland.

7.4.2 Moorland

Moorland / blanket bog was the largest single landscape zone in the Western Isles in general and Lewis in particular by the beginning of the first millennium BC and steadily expanded during the period of study (see Chapter 2). The most obvious resource for humans within this zone would be peat and the use of well-humified peat as the principal fuel has been established for the sites throughout the study area and period in Section 5.8.2. The widespread recovery of plant macrofossils of various species and plant elements from peaty turf, such as the smaller culm base and rhizomes, heather elements (charcoal, leaves, capsules and seeds), sedge seeds (*Carex* spp.) and other indicator species (see Section 5.7.3), can also be interpreted as indicating occasional use of the peaty turf removed as part of the peat cutting of blanket bog. For example, a metre section of peat can produce approximately one peaty turf and upper-fibrous peat unit for every 10 units of well-humified peat cut ('DR' MacCleod, pers. comm.). Both the peaty turf and the upper fibrous peat could be used to keep the domestic fire going overnight when needed due to their smouldering qualities (see Section 5.7.1). The experimentation outlined in Chapter 5 showed that the burning of peaty turf produced many times more Quantifiable Components than well-humified peat. Therefore, it only needs the occasional use of a piece of peaty turf to introduce a disproportionate quantity of carbonised macrofossil contamination into an ash deposit composed largely of well-humified peat ash.

In modern times and the recent past, a basic pattern for peat procurement is apparent across Atlantic Scotland (Martin, 1716; Fenton, 1978; Boyd & Boyd, 1990; author's observation and conversation with crofting community). Though the exact pattern is likely to be different in the first millennia, the basic requirements for economic extraction (assuming the principle of least effort) would be essentially the same. To extract peat from areas of blanket bog requires planning, social organisation and equipment. The planning involves getting enough people at the right place at the right points in the year for the cutting, the stacking, the collecting and the storage. The social organisation involves being able to raise enough labour to do the job effectively and also to maintain rights of extraction from an area. This could involve systems of territoriality or ownership of the moorland away from the permanent settlements in the less marginal land in the coastal fringe. The actual extraction will generally occur in the late spring and needs certain tools to be effective, for example specialised spades. These varied in detailed form from island to island in the recent past in the region and would cut the peat into manageable and easily dried blocks. The spades could be made of wood, though whale bone or the like could be used in the wood-scarce Hebrides. Fragments of flat spade-like objects of whale bone have been found on machair sites of first millennia date in the Western Isles (cf. Foshigarry in North Uist; Hallen, 1994) that could have been used for this purpose. The most effective drying method is then to leave the peat blocks stacked in small pedestals to be dried by the wind and sun for at least a couple of months. Clearly, the issues of ownership and rights of extraction must cover this period, as the peat will be left unguarded for a long time and free to be taken by the less socially inclined. The transport of the dried peat must then be undertaken by human or animal labour during the summer and a peat basket made of heather was discovered in an early first millennium AD context in the underwater excavations at Dun Bharabhat (Harding & Dixon, 2000). Finally, the peat must be stored for use throughout the rest of the year and overlap with the cycle repeated the following year. Again archaeological evidence for this stage in the peat cycle is occasionally found, for example the remnants of a peat stack were discovered in semi-waterlogged conditions of a small cell in the Cellular block at Loch na Beirgh (**LB-C**; Harding & Gilmour, 2000).

Another major resource from the moorland would be the varieties of heather. The most common heather by far in modern day Lewis is Ling heather. Charcoal, leaves, capsules and seeds of Ling heather pre-dominated in the blocks, though fragments of Cross-leaved heather leaves (*Erica tetralix*

L.) were also recovered from **DB-S**, **LB-C** and **BO-LIA**. Heather has a large range of uses including kindling, furnishings, thatch, fodder, basket manufacture, such as the peat basket from Dun Bharabhat (Harding & Dixon, 2000) and the Howe in Orkney (Dickson, 1994). Also different colour dyes from the various species and varieties (Bennet, 1994) and ale can be produced from the flowers (Dickson & Dickson, 2000). Ling heather roundwood was the most numerous species of charcoal recovered from most of the blocks (see Figure 7.20). Ling charcoal is easy to identify due to its characteristic dimpled outer surface and each fragment usually had relatively clear ring counts. Figures 7.23 to 7.28 present the ring counts for Ling heather (pith to bark) from the Early Iron Age through to Norse / Early Medieval blocks. The ring counts from blocks within each of the different periods were grouped together to create large enough blocks of data from which meaningful analysis could be undertaken.

The mature to degenerate age of Ling heather within blanket bog is between 16-30 years (Gimingham, 1960; Barclay-Estrup, 1971; Grime *et al.*, 1988) and for most periods the age profiles of the charcoal fragments were within the lower end of the scale. An assumption has been made by which a 'natural' Calluna heath would have a range of ages of heather (Barclay-Estrup & Gimingham, C H, 1969). Also, the burning of a range of ages of heather plants in a domestic hearth would produce a varied distribution of ring profiles. However this latter point is untested and so certain distributions, such as restricted ring count ranges, may be a function of the burning properties of heather in domestic hearths. To test this hypothesis would require a series of burning experiments, which is beyond the scope of this study.

The profiles from the EIA and N/EM periods had a broad range of ages, whereas the profiles from the MIA and BO-LIA/N periods trended more towards lower counts. The two LIA periods had very pronounced distributions with peaks of 7 years and 6 years growth for LIA-I and LIA-II periods respectively. It is proposed that these discrepancies in distribution between the periods reflect different procurement or management strategies of the heather resource. In other words, the broad range profiles (EIA and N/EM) show heather of various ages being burnt, whereas the profiles trending towards the lower counts (MIA & BO-LIA/N) and those with the pronounced distribution (LIA-I & II) reflect heather of a younger and more restricted age range being gathered. Humans could consider younger heather more economically useful. For example, younger heather would make better fodder as it is more succulent with net production in shoots at its maximum (Barclay-Estrup, 1970). Also, the optimum age for heather used for internal furnishings and thatch using traditional building methods is generally less than 10 years (Jim Crawford, pers. comm.).

This younger and more restricted age range may involve selective gathering of relatively young heather, either as whole plants or the more youthful parts of older shrubs. Alternatively, it may reflect the age profile of the plants in the moorland itself as a product of indirect or direct anthropogenic impact on the resource. Indirect impact could have been achieved through rough grazing by sheep (Barclay-Estrup, 1971), perhaps reflecting transhumance. Direct impact on the moorland may represent a form of heathland management, for example through the use of fire (Edwards *et al.*, 1995).

In this context it is interesting to note a rise and fall in the concentration of micro-charcoal during the early to late first millennium AD in a number of pollen sequences from across the Western Isles. These include Loch Lang (Bennett *et al.*, 1990), Loch Buialaval Beag and Loch a'Phuind (Fossit, 1996), Tob nan Leobag (Bohncke, 1988) and most significantly for the study area, Loch Bharabhat (Figure 4.3; Lomax & Edwards, 2000). Whatever the reason, the result is that younger plants or parts of plants were being routinely incorporated into domestic hearths, presumably reflecting the age of heather routinely handled on the settlement. Also, a chronological change in behaviour occurred throughout the first millennia. A relatively wide age range of heather was handled during the Early Iron Age blocks giving way to a younger, more restricted age range during the Late Iron Age, before returning to a relatively wide age range handled by the Norse period.

Another moorland resource of which evidence was frequently recovered was seeds from berried plants. The seeds included Bearberry (*Arctostaphylos uva-ursi* L. Sprengel), *Bilberry (Vaccinium myrtillus* L.), Cowberry (*Vaccinium vitis-idaea* L.) and Crowberry (*Empetrum nigrum* L.). Each was consumed and sometimes used as a dye in the recent past (Martin, 1716; Bennett, 1994). The seeds of the berries could have been brought onto the site accidentally as part of gathered heather or peat fuel. Alternatively, the berries could have been deliberately gathered. If this was the case, the seeds would be rarely exposed to fire, unless discarded or accidentally dropped into the hearth. Therefore, their use may be only rarely recorded in the archaeological record and so Ubiquity counts have been used to judge their frequency during occupation, rather than the proportion of the wild components. Figure 7.29 presents the Ubiquity scores for the four berried plants grouped together from each site block with at least 10 samples. The lack of berried plant seeds at **GE** and **GAL-N/M** may be explained by the very poor preservation of seeds at Gob Eirer and the small size of samples taken from the eroding face at Galson, rather than an absence of the plants during the occupation on the sites. Figure 7.30 presents the number of species of the four berried plants recovered from each site block with at least 10 samples. The actual number of species and a standardised number of species recovered are shown. The standardised number takes into account the variability of the number of samples within each block and the value was calculated using the formula below.

Standardised value for every 10 samples in block = (10 / number of samples in block) * actual number of berried species recovered from the block

The high Ubiquity score from Calanais kerb cairn may be a function of the burning of peaty turf containing seeds from berries of the previous summer when cut for fuel. Alternatively, it may reflect, along with the high Ubiquity score from An Dunan, the deliberate incorporation of the berries into the burning associated with funerary activity, as part of a form of structured deposition (see Section 6.5). The other blocks from Loch na Beirgh and Bostadh have all been interpreted as domestic in function and so the Ubiquity scores could indicate small-scale gathering of the berries to supplement the diet. Guinnerso had the highest Ubiquity score, as well as the highest number of actual and standardised number of species. The only other block to have all four berried species was **BO-LIA**, a function of the large number of samples (n=80) that is reflected in the much lower standardised value. It is proposed that these high scores reflect the greater importance of the gathering of berried plants at Guinnerso. This fits in well with the interpretation of the site as a sheiling for transhumance, as the berries would be a significant contribution to the diet in the later stages of the seasonal occupation during the mid to late summer.

Occasionally, indeterminate fragments of the pericarps of small berries or fruits were recovered from a number of blocks, including **CC**, **GUN-IA**, **LB-C** and **BO-LIA** & **LIA/N**. The pericarps probably represent carbonised remains of the berried plants as they were found only in the blocks with significant Ubiquity scores and species values for these plants. However, positive identification was not possible as no diagnostic features, such as seed impressions, were preserved. The carbonisation may only reflect accidental charring within the hearth but may also represent an accident during drying of the berries for storage over the winter. A pit fill within the floor of House 1 at Bostadh (S. 198; **BO-LIA**) contained six pericarp fragments. This might have been the remains of such as accident, mixed in with other material in the hearth and the ash redeposited.

The final resource from moorland and bogs that repeatedly appeared within the block assemblages was sedge (*Carex* spp.). The only diagnostic parts identified from the genus were the biconvex and trigonous fruits but some of the rhizomes could also have been from sedges. Figures 7.31 and 7.32 present the Ubiquity scores and proportion of the total wild components for sedge fruits from each site block with at least 10 samples or wild components respectively. In general, sedge fruits were very common with up to 100% Ubiquity at **CC** and between 5 and 20% of the total wild components for over half of the blocks. Why were they so numerous in most of the blocks? Sedge seeds are commonly produced when burning peaty turf (see Section 5.7.3) and it has been proposed that this fuel was occasionally used to keep the domestic fires smouldering over night. Also, the sedge could have been an important resource in its own right throughout the time period under study. The different species of sedge could have had a myriad of uses including furnishings, thatch and dyes. Sedges could also grow as part of the fodder from wet grassland and rough grazing areas in the more marginal land in the North Atlantic (Amorosi *et al.*, 1998). Figures 7.31 and 7.32 also show the Ubiquity scores and proportions of the wild components for small culm bases (<2 mm) / rhizomes. These are very common and usually comprise the largest group of the wild components in the blocks. Again, this may relate to fuel contamination from peaty turf but may also represent the constant incorporation into the hearth of small bits of fodder that was routinely stored or handled within the domestic setting. However, the taphonomic uncertainty stemming from carbonisation in the hearths precludes positive identification of detailed foddering practices.

7.4.3 Woodland

Wood and timber are the obvious resources from any woodland and the extent and management of shrubs and trees has been discussed in Section 7.3. There are also a number of other rare pieces of evidence suggestive of more small-scale and opportunistic gathering from any possible local woodland. Two hazelnut fragments were recovered from **GE** and **LB-C**, whilst four fragments were identified from **BO-LIA**. It is unlikely that nuts were traded or arrived as driftwood in great quantity and so their identification provides further evidence for limited local woodland at different times in the first millennia. The nutshell from **LB-C** is particularly interesting as a piece of wattlework made of coppiced hazel was found in the upper waterlogged levels of the preceding phase (**LB-R**; see above). Hazel nuts could be eaten raw, dried for storage (creating an opportunity for carbonisation) or used for cooking. For example, preliminary chemical analysis of internal burnt pot residues from Sollas wheelhouse has indicated that one pot had a burnt residue consistent with a hazelnut paste (Campbell, 2000). Single seeds of Rowan (*Sorbus aucuparia* L.) have also been recovered from **CC**, **GE** and **LB-C** indicating its local presence, perhaps on inaccessible cliffs away from stock (Pankhurst & Mullin, 1994). Another secondary resource from this sparse woodland could be foliage for fodder. In this context it is interesting to note higher levels of birch roundwood and timber than other deciduous species were carbonised in the hearths from many of the blocks. The use of birch twigs as fodder was inferred from the high frequency of bud scales in all samples from sites in the Western Settlement of Iceland, supported by a birch pollen count of approximately 98% in a sheep dung pellet from Sandnes (Amorosi *et al.*, 1998).

7.4.4 Seashore

The procurement of driftwood has already highlighted the importance of the seashore but another important resource that would have been gathered was seaweed. Seaweed would have had a number of uses including fertiliser, food and fodder but was probably not burnt as a fuel due to the acrid smoke that it produces (see Section 5.7.1). However, the ash of seaweed was said to be a very effective fertiliser in the recent past as it concentrates various minerals, such as phosphates and iodine, and could be used for medicinal purposes and curing fish and meat (Martin, 1716). The deliberate production for ash would clearly preserve some of the seaweed through carbonisation. However, seaweed fragments have only been systematically removed from the 2 mm flots and residues from Bostadh and so it is impossible to judge the extent to which seaweed appeared in the block assemblages. In general, the fragments were scarce with only one sample from the main floor level in House 3 (**BO-LIA**) containing over a thousand fragments of seaweed thalli. This deposit may reflect the deliberate production of seaweed ash. Very small molluscs have also been found throughout the three main phases at Bostadh, including *Cingula cingulus* (Montagu), *Rissoa parva* (da Costa) and a tube-dwelling polychaete, *Spinorbis borealis* (Daudin), which are typically associated with seaweed. Some of these were burnt, again suggesting the deliberate production of seaweed ash (Ceron-Carrasco, forth.).

7.4.5 A note on the medicinal use of wild plants

Plants would have almost certainly have been gathered and used for medicinal purposes but as Dickson (1994) indicated providing definitive evidence for medicinal use is almost impossible. This is again a function of the mixed taphonomy, by which a carbonised seed of Bilberry may be derived from the fuel, or deliberately collected for food, dye or alternatively as an astringent. Indeed, observation of the medicinal use of plants in the recent past (cf. Martin, 1716; Fenton, 1978; Bennett, 1994; Dickson & Dickson, 2000) has highlighted that many of the plants found on archaeological sites have been used for medicinal uses in some form or another. Therefore, no detailed discussion has been attempted on this issue because of the uncertainty of derivation and taphonomy for many of the wild components.

7.5 Integrating the evidence: the theoretical economic landscape and annual cycle

This chapter has highlighted the main resources and zones of exploitation in the landscape that were repeatedly used throughout the first millennia. Essentially, though the nature of resource exploitation changed slightly from domestic block to block, there seems to be two main periods of similar economic practice for which there is a large quantity of data. The first period relates to the Mid to Late Iron Age I blocks (**LB-R** & **C** and the all the blocks from Dun Bharabhat, Cnip, Guinnerso) and the second period relates to the Late Iron Age II to Norse blocks (**LB-LIA** and all the blocks from Bostadh and Galson). In both periods, five main zones of exploitation can be identified to form a theoretical economic landscape for most domestic blocks. The zones include:

1) arable zone (crops grown and harvested).
2) moorland (peat , heather, berries and sedges collected).
3) shoreline (seaweed and driftwood collected).
4) small areas of managed woodland/inaccessible cliffs for deciduous and pine timber procurement (limited management and control).
5) rough grassland for grazing and production of fodder.

This provisional model does not represent landscape reconstruction in the physical and spatial sense, but rather highlights an economic landscape that can be reconstructed to a greater or lesser extent for most sites that produce ecofactual and artefactual assemblages. A reconstruction of the physical economic landscape is only possible through the integration of the off-site palaeoenvironmental proxy records, such as pollen. Such integration allows the resources to be placed in their landscape context. The Mid Iron Age and Late Iron Age I blocks from the Bhaltos peninsula represent a good case study. In this example, the zooarchaeological evidence from the sites is also taken into account (data from Ceron-Carrasco *et al.*, forth.)

Figure 7.33 demonstrates the likely position for most of the resources within the peninsula. It can be seen that the rocky shore provides access to many resources including saithe, driftwood, seaweed, molluscs, sea mammals and seabirds that would have been harvested from the shoreline. It is proposed that the whole coastline would be 'owned' by different human groups, so that the resources could be taken at the optimum times, without fear of others taking them first. Whether this 'ownership' was based on the level of the community or smaller groups is impossible to evaluate but some form of control over the harvesting of the resources would have been required. The key is the existence of a social mechanism covering an area that enables disputes over resources between human groups and settlements to be ultimately resolved in a fair and peaceful way. This would be particularly important for driftwood collection, especially during the autumn and winter storms. Further inland the machair was used for the cultivation of crops, barley being predominant in the archaeological record, with possible field rotation with limited stock grazing. The numerous lochs could have been harvested for rushes and reeds for bedding and basketwork, as well as being fished for trout and eels. A possible copse of mainly pine near to Dun Bharabhat would have provided some of the structural timber for the sites. Also, coppiced hazel from an unknown area and individual trees/shrubs in inaccessible places, such as cliffs, could have provided internal furnishings and the like. The upland wet grassland is likely to have provided grazing and perhaps fodder for stock. These uplands and the moorland provided a wide range of plant resources including heather, various berries, bracken and isolated small shrubs / trees. Movement of red deer is likely to have been restricted to these areas as deer and crops in the machair would have been incompatible. Finally the moorland provided peat for fuel, and fertiliser from the ash. Although there is no extensive blanket bog on the Bhaltos peninsula itself today, there is easily accessible deep, well-humified peat nearby on the Uig peninsula, which was also the case in the Iron Age (Flitcroft, 1997).

The economic landscape described above can be regarded as a core area in close proximity to the sites, with a hinterland comprised of the wet upland grassland and the heathland. The core area would have contained most of the staple food sources including the crops, the marine resources and some of the animal husbandry. The hinterland would not have been as intensively settled and used, but would still have been an important area for peat and plant procurement, summer transhumance and perhaps the management of red deer. The site at Guinnerso represents the sort of structure used in the summer months, akin to a sheiling.

The similarity between the site assemblages suggests a marked degree of continuity of economic practice in the study area, over a period of half a millennium. There is also evidence, from the mineral magnetic analysis of peat ash for example, of repeated localised exploitation throughout this time. Figure 7.34 compares the archaeological ash samples from the three sites to the discriminant analysis of the experimental results outlined in Chapter 5. This illustrates that well-humified peat was the main fuel type, with a consistent magnetic signal from some of the samples plotting just to the right of the experimental data. The pattern has been interpreted in the light of the analysis on other sites across Lewis (Figure 5.24) as representing a specific regional source for the three sites. This may indicate a formalised division and tenure of the landscape that was established for the Bhaltos Peninsula and which was attached to the site and the region, as opposed to a specific tribal lineage. In other words, the same peat banks were maintained for many generations by the people who lived in the immediate area around Traigh Cnip, Traigh na Beirgh and Loch Bharabhat, linking specific core economic zones with specific areas of the hinterland. The hypothesis could be tested further by comparing the phytolith components within the ash, as a pilot study has shown that the suite of phytoliths vary subtly between different well-humified peat sources (Westoby, 2001).

There is also a seasonal dimension to these theoretical economic landscapes, highlighting the annual cycles of plant procurement and management. Figures 7.35 and 7.36 present these cycles for the domestic blocks from the Mid Iron Age to Late Iron Age I and the Late Iron Age II to Norse respectively. Both cycles require detailed planning and organisation of labour, as well as stability in land holding and the existence of social controls over the various resource zones, for example the peat banks and shorelines. It can be seen that the annual cycle in the later period displays increased complexity. For example, the introduction of oat and flax represents an extensification of the arable economy, a concept explored in more detail in the next chapter. Also, the extra time, labour and planning needed for flax fibre processing during the later period is apparent, highlighting the economic decisions that would have been needed to grow and process the crop for cloth manufacture.

7.6 Conclusion

This chapter has highlighted the main building blocks of the plant economy. A continuity of practice seems to have been in place for hundreds of years, with significant modifications only occurring towards the end of the first millennium AD. The next chapter will explore whether aspects of this continuity and change can be seen across the rest of the Western Isles and the wider region of Atlantic Scotland, focussing on the arable economy and wood and timber procurement.

Chapter 8: Cereal agriculture and wood procurement in Atlantic Scotland

8.1 Introduction

8.1.1 General

This chapter compares the major findings from the West Lewis data set to the wider regional evidence across Atlantic Scotland. However, such a review needs to take into account the variability in the detail of the published data, so many of the comparisons are qualitative rather than fully quantitative. Aspects of the arable economy and wood procurement are considered as only these two research themes are routinely described from the archaeobotanical assemblages identified throughout the 20th century. Regional similarities and differences in the plant economy of the first millennia are highlighted. Finally, a number of methodological and interpretative issues are identified for future research.

8.1.2 Assembling the data set

Atlantic Scotland was first split into five areas including a) Shetland b) Orkney c) Caithness and Sutherland d) Argyll, Inner Hebrides and Skye and e) the Western Isles as a whole. These areas reflect recognised geographical, cultural and archaeological areas of research (cf. Armit, 1990a; Henderson, 2000b). The data set was based on any published archaeobotanical remains from sites with occupation in the first millennia in these five areas. The literature search was based on evidence extracted from the Archaeobotanical Computer Database (ABCD; Tomlinson & Hall, 1996), a literature review of the *Proceedings of the Society of Antiquaries of Scotland* and *Glasgow Archaeological Journal* and other monographs and journals with relevant information known to the author or other colleagues. Dickson & Dickson (2000) and other papers (cf. Dockrill *et al*., 1994) were also consulted for interim statements on large site assemblages still awaiting publication. Only published data was used and no reference to material in the NMRS was undertaken due to time constraints. Table 8.1 presents the 43 site assemblages from four of the areas (see Section 2.5.14 and Chapter 6 for Western Isles assemblages). The 43 sites were broken down into 67 chronological blocks of analysis using the relatively coarse dating scheme outlined in Section 4.2.4. Multi-period sites such as the St. Boniface in Orkney were split into a number of blocks of analysis. Also, stratigraphic and chronological resolution in certain publications was insufficient even for this scheme and so some blocks were very broad, for example the Mid/Late Iron Age block from Gurness. Unfortunately, it was usually impossible to differentiate between the two Late Iron Age sub-divisions and so a generic Late Iron Age block was routinely noted.

Table 8.2 presents a statistical breakdown of the composition of the data set. It can be seen that over 60% of the blocks came from the Northern Isles, with fewer sites from the mainland areas. Also, the sampling strategies employed varied between areas with detailed *total* sampling more in evidence in the Northern Isles. Indeed, only two of the 19 sites on the mainland employed *total* sampling and both of these were in Caithness and Sutherland. This discrepancy reflects the type of research excavations on multi-period settlements that have occurred in the Northern Isles over the past 20 years and highlights the relative lack of such projects on mainland Atlantic Scotland, especially in Argyll. Overall, the material included hand-retrieved (28%) and bulk *judgement* samples (28%) from earlier excavations or bulk *total* samples from the more detailed sampling exercises (44%). The chronological coverage of the entire data set was relatively even, though regional variation can again be seen. For example, wide chronological coverage can be seen in the Northern Isles, especially Orkney, but the Norse period on the mainland is under-represented. This is obviously a function of the geographical extent of the 'Scandinavian influence' (Ritchie, 1993), but also reflects a general absence of Norse excavations in the Atlantic mainland and West. Most of the remains were carbonised plant macrofossils (75%) and charcoal (76%), with a single site revealing human coprolites (Warebeth broch in Orkney) and uncarbonised plant remains and wood from a Late Iron II ditch fill in Iona. Therefore, it is assumed that the majority of the material accumulated in the sites through the taphonomic model outlined in Chapter 5, apart from rare special deposits, such as conflagrations or the remains of *in situ* crop-processing accidents. Differentiation between roundwood and timber was rarely mentioned and so the identification of genera was usually noted as timber.

Most of the remains were noted on a qualitative and semi-quantitative basis only as much of the material was published in insufficient detail to attempt the level of analysis undertaken in West Lewis. Tables 8.2 to 8.6 present the archaeobotanical assemblages for each area, in block chronological order. Three levels of recording were made depending on the detail given in the publication. The first and most basic level was a qualitative presence and abundance score, used mostly in connection with hand-retrieved material, small assemblages or interim statements with little reference to sample counts. The second level involved calculating Ubiquity scores for sites with greater than 10 samples, used mostly in connection with relatively detailed sampling of modern sites. The final level involved calculating the proportions of cultivated genera from certain site blocks with at least 100 cultivated seeds/grain. This required publication to include details of all of the individual sample counts from the generic context types in a single block (Table 8.8). This level of analysis was only possible on a few of the assemblages, highlighting the low priority given to publication of the raw data.

8.2 Cereal agriculture

8.2.1 "What crops are found on the sites and does this change over space and time?"

Shetland

Seven sites comprising 17 blocks of analysis running from the Early Iron Age to the Norse period were sampled in Shetland (Table 8.3). Six blocks had sufficient published information and samples for Ubiquity counts and proportions of cultivated genera were calculated for five of these blocks (Table 8.8). Hulled barley was the dominant crop throughout the first millennia, with all of the identifiable rachis internodes and the symmetric:asymmetric ratios of the grain indicating the presence of only the six-row species. Naked barley was present in most of the larger assemblages but only in very small quantities. Therefore, it is unlikely that the variety was grown in its own right, its recovery instead reflecting slight contamination of the largely hulled crop. Emmer wheat was only recovered in small quantities from East Shore Broch and also represents likely weed contamination of the barley crop. Significant quantities of oat were recovered from over half the blocks and appeared at Kebister and Scalloway from the Mid Iron Age onwards. Floret bases were rare but when identified indicated Black oat (A. *strigosa* type). It therefore seems reasonable to suggest cultivation of oat from the Mid Iron Age with increased use throughout the first millennium AD. Flax was recovered in low quantities from only three blocks from the Late Iron Age I onwards and so its cultivation seems to vary between sites. Also, the identification of flax seeds from a single context in the Late Iron Age block at Kebister may have reflected contamination from later deposits (Dickson, 1999; Holden & Boardman, 1998) and so flax cultivation can only be suggested with any certainty from the Norse period onwards.

Orkney

17 sites comprising 24 blocks of analysis running from the Early Iron Age to the Norse period were sampled in Orkney (Table 8.4). Nine blocks had sufficient published information and samples for Ubiquity counts and proportions of cultivated genera were calculated for four of these blocks (Table 8.8). Throughout the first millennia the dominant crop was barley, with all of the identifiable rachis internodes and the symmetric:asymmetric ratios of the grain indicating the presence of only the six-row species. However, unlike in Shetland hulled barley was not dominant throughout the period and both varieties were grown at various times. For example, only naked barley was handled during occupation at three of the five Early Iron Age blocks with only one block (**TN-EIA**) with hulled barley dominant. Both varieties were being grown at the same time but always with one variety dominant over the other. Therefore, people were making choices over which variety to grow depending on taste, cultural preference or the micro-climate and local conditions of their immediate economic landscape. This situation continued into the Mid Iron Age but by the Late Iron Age onwards, hulled barely was the dominant crop, with the naked variety essentially a weed contaminant. Emmer wheat was recovered from only two Early Iron Age blocks from Bu and the Howe, again in small quantities. This could either represent weed contamination of the barley crop or the final attempts at very small-scale emmer cultivation, characteristic of the earlier millennia in the Northern Isles.

Oat appears for the first time in the Mid Iron Age but seemed to be insignificant until the Late Iron Age. In the Norse period oat at certain sites, especially those around Birsay Bay, seem to contribute approximately the same, and in some cases more, to the arable economy as the barley. Again, where further identification was possible, Black oat was the species selected for cultivation. This rapid elevation in importance seems to coincide with the Late Iron Age II / Norse transition. Flax was recovered from over half of the Late Iron Age and Norse blocks and again its selection as a crop seems to vary between sites. However, its presence in human coprolites of Late Iron Age date in the well from Warebeth broch suggests its use as a foodstuff was well established by this time.

Caithness and Sutherland

Six sites comprising 11 blocks of analysis running from the Early Iron Age to the Norse period were sampled in Caithness and Sutherland (Table 8.5). Four blocks had sufficient published information and samples for Ubiquity counts and proportions of cultivated genera were calculated for all of these blocks (Table 8.8). However, the very small number of statistically representative blocks in the area means detailed chronological and social interpretation can only be tentative at present.

Throughout the first millennia the dominant crop was barley, with nearly all of the identifiable rachis internodes and the symmetric:asymmetric ratios of the grain indicating the presence of only the six-row species. The only block in the entire data set that hinted at the presence of two-row barley was the Early Iron Age hut circle complex at Upper Suisgill, with a symmetric:asymmetric ratio of 1:0.97. However, the few rachis internodes recovered from the block were identified as the six-row species. Again, like in Orkney hulled barley was not dominant throughout the period and both varieties were grown at various times. Naked barley was dominant at four of the seven Early Iron Age / Mid Iron Age blocks, with only two of the blocks showing hulled barley dominant. Again, the cultivation of the varieties seems to be occurring at the same time in different points in the area, but always on a mutually exclusive basis rather than a mixed crop. Various species of wheat were recovered throughout the first millennia including emmer, spelt and bread wheat. None of these were dominant in the assemblages and again may reflect weed contamination or the final attempts at very small-scale wheat cultivation, characteristic of the earlier millennia in the area. The single block with rye from a grain storage pit at Cyderhall represents weed contamination of the hulled barley crop.

Oat was recovered from almost all of the blocks throughout the first millennia. Most of the blocks from the Early to Mid Iron Age had very small quantities, reflecting probable weed contamination, but almost 10% of the proportion of grain from the Early Iron Age block from Upper Suisgill was oat, suggesting cultivation in its own right. This small-scale cultivation seems more widespread during the first half of the first millennium AD, with again a marked increase in importance in the Late Iron Age II and Norse periods. The increase seems to occur slightly earlier than in Orkney with the Late Iron Age II block at Freswick containing equal numbers of hulled barley and oat. Flax was recovered from only three blocks, with two of these coming from the later first millennium AD deposits from

Freswick. However, the other block was from the Mid Iron Age deposits at Crosskirk broch that represents the earliest recovery of this species in the data set. The fact that this early recovery was associated with inhabitants of a broch complex (not necessarily the broch itself) may support the proposed correlation between the cultivation of flax and social hierarchy. Another interesting find is the two carbonised pulses of Celtic bean in a midden from the Norse levels at Freswick. This represents the earliest dated recovery of this species in Atlantic Scotland and though two pulses do not indicate cultivation in themselves this cannot be discounted as it is unlikely that they would be routinely exposed to fire during their processing, unlike the cereals. Therefore, pulses would be under-represented in the record.

Argyll, Inner Hebrides and Skye

13 sites comprising 15 blocks of analysis running from the Early Iron Age to the Late Iron Age II period were sampled in this area (Table 8.6). Only one block (**BH-MIA**) had sufficient published information and samples for Ubiquity counts and proportions of cultivated genera were calculated for the Early Iron Age block from Dun Mor Vaul (Table 8.8). Therefore, detailed interpretation is limited for this area. Hulled barley was the dominant crop throughout the first millennia, with all of the identifiable rachis internodes indicating the presence of only the six-row species. Naked barley was present in some of the blocks but only in very small quantities. Therefore, it is unlikely this variety was grown in its own right and its recovery represents slight contamination of the largely hulled crop. Emmer wheat was recovered in small quantities from three of the blocks of Mid and Late Iron Age date and may reflect weed contamination or the final attempts at very small-scale wheat cultivation, characteristic of the earlier millennia in the area. Oat is also present from the Mid Iron Age but only occurs in significant quantities in the Late Iron Age blocks of Dunadd and Dun Beag. Therefore, oat cultivation probably became important during the mid to late first millennium AD. An importance absence from the blocks in this area is flax. This is mainly a function of the absence of Norse period blocks and sites but may also reflect a real absence of cultivation.

Synthesis

Subtle regional differences in the selection and uptake of different cultivated crops occurred across Atlantic Scotland throughout the first millennia. Barley was the dominant crop for most of the blocks, with the six-row species identified from all but one of the blocks containing barley. This seems to be at odds with the evidence from West Lewis, where two-row barley was present in significant quantities in a number of the domestic blocks (see Section 7.2.2). The discrepancy is hard to explain. It may be due to certain qualities that the two-row species has that made it flourish in the mixed crops in West Lewis, dependent on the micro-climate and environmental conditions on a coast receiving the full force of the Atlantic. Alternatively, it may be a function of recognition by specialists as the two-row rachis internodes with attached sterile spikelets from the conflagration level at Dun Bharabhat were only slightly more elongated and narrow at the shoulder than the equivalent six-row internodes in the same level. Therefore it is possible that a few of the internodes identified as six-row across the rest of Atlantic Scotland may in actual fact be of the two-row species but that these were not sufficiently preserved for the sterile spikelet bases to survive. Only five out of a possible 50 blocks that contained macrofossils had a sufficient level of published detail to estimate the symmetric:asymmetric ratio and one of these **(US-EIA)** indicated a mix of six and two-row barley. Therefore, the apparent absence of the species across the rest of the region may be a function of the analytical and reporting taphonomy.

Variability existed between the different areas in terms of the selection of the barley variety. In general, hulled barley was dominant throughout the first millennia in Shetland and the Atlantic West, with the occasional recovery of naked barley as a contaminant of the hulled crop. This occasional presence occurred throughout the first millennia in Shetland and Argyll, with no increase in Ubiquity during the Early Iron Age and Norse periods, a phenomenon noted from West Lewis (see Section. 7.2.2). However, in Orkney, Caithness and Sutherland the situation was more complex. From the Early to Mid Iron Age, both varieties were grown at the same time, though apparently in mutually exclusive crops with little mixing. It was only during the first millennium AD that the naked variety was gradually phased out in favour of hulled barley. This pattern has important implications. Firstly, for the mutually exclusive yet contemporary cultivation of both varieties to occur would require the expertise and facilities needed for selection. In other words, it is likely that most farming communities in Orkney, Caithness and Sutherland would have the cultivation expertise to make the choice of the best variety that fits in with their arable economy. This would require access to a sophisticated system of seed varieties on the macro-regional level, both for experimentation and also long-term cultivation. This would also provide the mechanism for the transfer of knowledge of different crop types and the actual crop itself in the form of seed. In this way, weed ecologies are also transferred that can explain the occurrence of small amounts of crop types, such as oat and flax, generations in advance of deliberate cultivation in the immediate economic landscape.

The second major implication is the differing generic strategies that seem to have developed in the region. For example, hulled barley may have been the dominant variety in Shetland and the Atlantic West throughout the first millennia due to the over-riding climatic control following the Late Bronze Age climatic deterioration. Hulled barley would stand up to the rigours of the increased oceanicity, due to its relative tolerance of damp conditions. Conversely, naked barley was grown more frequently than the hulled variety in Orkney and the north and eastern areas of Caithness and Sutherland as the climate was slightly less influenced by the Atlantic ocean. Therefore these areas would still be able to sustain the economic viability of naked barley and its easier crop-processing qualities. In this context it is interesting to note that the naked form was gradually replaced by the hulled variety throughout the first millennium AD. This may be a function of the worsening of the climatic conditions but this is not necessarily supported by the regional palaeoclimatic reconstruction (see Section 2.4). Alternatively, the use of hulled barley may reflect the increased importance of long-term storage as the tightly enclosed lemma and palaes make the hulled variety less susceptible to damp and rodent damage (see Section 8.2.3 below).

The uptake and cultivation of oat is also not uniform across the region. In Shetland, significant quantities first appear in the Mid Iron Age with increased use throughout the first millennium AD but with no obvious dramatic increase at the end of the millennium. In Caithness, significant quantities were recovered from Early Iron Age blocks, though the general pattern was again one of increased use throughout the first millennium AD. In Orkney, oat is present in a number of Mid Iron Age assemblages but only in very small quantities and so has been interpreted as a weed contaminant of the barley crop. This contamination may stem from barley seed traded from Shetland and the mainland, where evidence of contemporary cultivation of oat has been found. Again, increased use of oat in Orkney throughout the first millennium AD is noted but with a significant increase in proportions of the assemblages at the Late Iron Age II / Norse transition, a pattern similar to that observed from the Western Isles.

This somewhat confused picture can be interpreted in a number of ways. The early uptake in oat in Shetland and Caithness may reflect different selection processes. It can grow in very marginal environments and so would be a useful addition in the immediate economic landscape of Kebister and Scalloway in Shetland and the marginal uplands surrounding Upper Suisgill. The Early Iron Age uptake of oat at the latter site reflects the wider diversification of the arable base across mainland Scotland (Boyd, 1988; Armit, 1999; Dickson & Dickson, 2000) and Britain as a whole (van der Veen, 1992; van der Veen & O'Connor, 1998) in the Iron Age. The presence of various types of wheat in the mainland assemblages also suggests the influence of earlier cultivation practices and lowland arable practises operating in the wider context of Northern Britain. In other words, though the wheat was not seen as a significant resource in its own right the exchange of seed and grain between the Atlantic areas and the lowland areas such as the South-west and North-East repeatedly introduced the wheat into the local weed ecologies.

The use of oat in Shetland however, would perhaps best be explained as a calculated response to increased marginality stemming from the climatic deterioration of the first millennium BC. This response was undertaken later in Orkney and the Western Isles, the two island groups that also saw a significant increase at the Late Iron Age II / Norse transition, suggesting a Scandinavian rather than a mainland over-riding influence operating at this time. This Scandinavian influence also seems to be reflected in the widespread uptake of flax cultivation. This occurs sporadically throughout the Late Iron Age but another significant increase in the number of sites with flax recovered occurs at the Late Iron Age II / Norse transition. Again, this can be interpreted as the imposition of an arable regime on the local populace or a more integrated approach undertaken by Norse settlers. However, the fact that the earliest flax identified in Atlantic Scotland occur in the elaborate hearth at An Dunan and a related broch context at Crosskirk hint at the perceived importance of the crop and the beginnings of the possible social stratification associated with its cultivation. This can be seen throughout the region in the first millennium AD with differential uptake and presence occurring between sites.

8.2.2 "Where were the crops grown and how were they processed?"

General

Most of the site blocks with detailed sampling produced assemblages with grain, a little chaff and a variety of wild components, some of which would have been weed contaminants of the cultivated crops. However, in most cases the taphonomy of the carbonised remains means pinpointing the position of cultivation in the wider environment is plagued with the same difficulties outlined earlier in this study. Essentially these can be summarised as follows;

a) the unknown quantity of mixing within a typical assemblage derived from a domestic hearth.
b) the poor preservation resulting from this carbonisation process that produces assemblages dominated with hardier plant parts, such as grain and culm bases / rhizomes. The less hardy elements, such as the chaff and weed seeds, are much more easily destroyed, leading to under-representation and rarity of these elements.
c) usually only the later stages of crop-processing are exposed to carbonisation in the central hearths and so the weed seed and chaff rich deposits from the earlier stages are under-represented.

Despite these inherent problems a number of researchers have suggested likely positions for cultivation in the wider landscape. This is usually based on the archaeobotanical assemblage from a site as a whole but also includes reference to rarer deposits, such as conflagration deposits and *in situ* crop-processing accidents, that overcome some of the problems outlined above. Also, researchers in some of the larger campaigns have also located and sampled contemporary field systems to the excavated sites that allows a greater potential in successfully locating the actual position of the arable fields. The various sites where the wider position of cultivation has been estimated are outlined by area below.

Shetland

The only two of the site assemblages that contained information regarding where the crops were grown and how they were processed were the broch / post-broch settlements at Upper Scalloway (Holden & Boardman, 1998; Holden, 1998) and Old Scatness (Bond *et al.*, forth. a & b). Holden (1998) acknowledged the mixed composition of the assemblage as a whole but suggested that the recurrent recovery of certain wild components associated with grain or straw pointed to barley cultivation in the base-rich soils of the Tingwall valley, adjacent to the site. He also highlighted the common occurrence of Chickweed (*Stellaria media* L. Vill.), suggesting soil amendment. Oat became increasingly important as a crop in its own right in the Late Iron Age and Holden suggests that its use meant more marginal land, of both increased acidity and alkalinity, could have been brought under cultivation. At Scatness an integrated sampling programme has allowed these concepts to be expanded and thoroughly tested. On-site bulk sampling has indicated that hulled six-row barley was the main crop for most of the Iron Age sequence, with oat becoming increasingly important throughout the first millennium AD. Coring and test-pitting of the immediate area has highlighted a number of contemporary cultivated soils immediately adjacent to the settlement (Batt & Dockrill, 1998; Simpson *et al.*, 1998). Preliminary analysis of these soils has shown increased amendment throughout the first millennia. Bond *et al.* (forth. a & b) have suggested that this base-rich sandy soil was used for intensive cultivation of the barley, with the oat being grown in more marginal areas, using less intensive methods. In this way, they argue that this reflects the beginnings of the infield / outfield system common throughout Atlantic Scotland in the Medieval period.

Little unequivocal evidence for crop-processing was recovered from Scalloway, as most of the grain seemed to have been carbonised in the final stages. However, a roof fire in one of the post-broch phases yielded a large cache of grain, presumably stored in the roof itself. Little information was provided on how the grain was stored (i.e. was it stored fully processed or in ear form) but the act of storage in itself may have been a reflection of the status of the inhabitants of the broch complex within the wider social and economic landscape (Dockrill & Batt, forth.). Also, straw culm bases and low-lying weed seeds, such as Chickweed, were routinely recovered from all phases at the site indicating the importance of the straw resource and the strategy of uprooting to maximise the yield.

Orkney

A number of assemblages from Orkney contained information regarding agricultural practice. The earliest discussed was the Early Iron Age assemblage from Bu, where Dickson (1987a) suggested, from ethnographic parallels, that the barley ears were individually plucked, leaving the straw and low-lying weeds to be reaped near the base of the straw and gathered for thatch or animal bedding. However, no direct evidence for the separation of the harvesting episodes was recovered from the site so this hypothesis is impossible to test.

At the multiphase settlement at St Boniface, Boardman (1999) argued that the level of mixing and relatively low concentrations of cereal remains meant questions of cultivation practice could not be answered. In view of the soil micromorphological results from the major midden levels, this was an appropriate position to maintain as peaty turf seems to have been widely used as fuel (Carter 1998a, 1999), introducing large quantities of archaeobotanical contaminants to the wider assemblage. This was also true of much of the assemblage from the Howe, where Dickson (1994, 1998) argued through the plant remains themselves that peaty turf was also widely used. However, one of the more important aspects of the excavations at this site was the recovery of a number of *in situ* crop-processing accidents and structural conflagrations at various points across the site. As argued above (Section 6.3.5), in these deposits it is possible to be more confident of the direct association of the plant remains with certain behavioural episodes, such as crop-processing, than within more mixed assemblages carbonised in the domestic hearths. Therefore, it should be possible to reconstruct crop-processing practice and the weed ecologies from such remains. A conflagration within the Late Phase 7 occupation of the broch preserved individual ears of naked six-row barley laid out to dry adjacent to the warmth of preserved kilns and ovens. Contemporary deposits of straw in a separate Phase 7 conflagration in the SW house had no rachis internodes attached and had a specific suite of weed seeds. Generally, these deposits were indicative of relatively fertile, amended sandy soils, but the presence of certain species, such as Common spike-rush (*Eleocharis palustris* L.), may suggest more damp ground was also brought under cultivation. It is possible to propose from the evidence that the ears were first plucked and then dried and the straw harvested separately. Again the presence of straw culm bases and low-lying weeds suggested up-rooting to maximise the straw yield.

The numerous assemblages of Late Iron Age and Norse date from around Birsay Bay (Donaldson, 1986b; Donaldson & Nye, 1989; Nye, 1996) indicated cultivation on the local sandy soils. This was suggested due to the recurrent recovery of certain species, such as Wild turnip (*Brassica rapa* L.) and Corn spurrey (*Spergula arvensis* L.) that would have flourished in the lighter soils. Chickweed was again routinely identified that may indicate amendment strategies in place. Significant quantities of burnt seaweed were also recovered, the ash being a possible fertiliser. The Norse hearth complexes excavated at Beachview contained concentrations of cereal grain with some chaff, which led Nye (1996) to suggest that the final drying of the grain was undertaken within these areas.

Caithness and Sutherland

Only three assemblages from this area contained information regarding agricultural practice. The earliest assemblage stemmed from the detailed inter-disciplinary work undertaken within the Lairg valley. Holden (1998a) suggested that the majority of the crops recovered were grown in the field systems immediately adjacent to the various structures excavated. The vast majority of the wild components indicated spring sowing of the crop and again intensively tilled and amended soils were suggested by the recovery of large quantities of seeds of Chickweed and Fat hen (*Chenopodium album* L.). The taphonomy of some of the deposits suggested to Holden that the absence of certain weed seeds was real, rather than stemming from a preservation bias, and so he proposed that weeding was also routinely undertaken. The recurrent recovery of such low-lying species as Chickweed and Creeping buttercup (*Ranunculus repens* L.) was in keeping with this suggestion as they would be harder to remove than more obvious species, such as the docks (*Rumex* spp.), that were under-represented in the assemblage. Little in the way of chaff was recovered, a function of the taphonomy, carbonisation processes and the thoroughness of the threshing and cleaning of the crop.

The grain storage pit from Cyderhall also provided useful insights into agricultural practice as the wild components preserved are more likely to be direct weed contaminants of the barley crop than the more mixed assemblages usually analysed. The weed assemblage indicated growth in the surrounding free-draining deep soils, the optimum conditions for cultivation in the area, with again some indicators of areas of damp ground, perhaps as wetter hollows in the soil (Boardman, 1992). The relative absence of Chickweed may suggest a more limited amendment strategy than proposed for many of the assemblages across Atlantic Scotland. Boardman suggested that the barley was stored as whole ears due to the approximate ratio of 1:3 for rachis internodes to grain, as well as the recovery of many awn fragments.

The Late Iron Age and Norse deposits from Freswick produced approximately equal numbers of six-row hulled barley and cultivated oat, associated with a few arable weed seeds of species characteristic of light sandy soil, such as Corn spurrey, as well as those of heavier soils, such as Mayweed (*Anthemis cotula* L.). The sections sampled were all recorded in coastal sandy soils but Huntley & Turner (1995) suggested local cultivation was not practised, due to the weed seeds indicating heavier soils and the lack of barley pollen in a local pollen core. However, this interpretation is somewhat at odds with the multiple cultivation horizons from which most of the Late Iron Age plant macrofossils were recovered. Therefore, an alternative interpretation could be that the barley crop was grown within the lighter soils, whereas the oat crop was grown in the more marginal damp, clay soils.

Western Isles

The only site report containing information regarding agricultural practice from the other archaeobotanical assemblages in the Western Isles (see Section 2.5.14) was Dun Vulan. Smith (1999) suggested that the strong correlation of Heath-grass with grain in the Mid to Late Iron Age midden was indicative of cultivation of barley in the interface between the machair and the peaty 'blacklands' inland. During the Iron Age it has been estimated that this would have been at least 2 kilometres from the site. She also suggested that the presence of significant quantities of culm bases and Chickweed seeds was indicative of up-rooting in an amended soil. However, this is at odds with the evidence from most other sites that suggests the arable fields were usually very close to the sites excavated. The presence of Heath-grass seeds (*Danthonia decumbens* L.) in such numbers could alternatively be a function of the burning of peaty turf and examination of the other recurring species supports a mix of arable weeds and fuel contamination. Also, no differentiation has been given for the size of the culm bases and so an unknown proportion could also have been introduced with peaty turf fuel. In this context it is interesting to note that preliminary mineral magnetic analysis from ash deposits from the Late Bronze Age site of Cladh Hallan, close to Dun Vulan on the South Uist machair, has indicated a mix of peaty turf and well-humified peat (Church *et al.*, forth.). Though approximately a thousand years earlier than Dun Vulan this may indicate a slightly different fuel procurement strategy existing in South Uist to that suggested for West Lewis, with the greater use of peaty turf in South Uist introducing a more pronounced fuel contamination for the archaeobotanical assemblages. A more systematic programme of mineral magnetic sourcing would be needed in the area to test this hypothesis.

Argyll, Inner Hebrides and Skye

Only the assemblage from Dunadd contained information regarding agricultural practice. Unfortunately, no differentiation was made between the Mid and Late Iron Age phases in the archaeobotanical report (Milles, 2000) and so interpretation is limited. However, the persistent recovery of larger culm bases, weed seeds and barley chaff led Milles to propose local cultivation of the crop, rather than grain being brought onto the site as a tribute, the consensus of the contemporary documentary evidence for royal sites such as Dunadd. However, despite the presence of culm bases she discounted the use of up-rooting in harvesting as none of the weed seeds were low-lying. Further interpretation on agricultural practice was not possible, due to the relatively small and poorly preserved assemblage.

Synthesis

In general, detailed interpretation of agricultural practice was only possible from sites where rigorous bulk sampling was undertaken. Therefore, the key points summarised here are not based on the full data set and will almost certainly require revision in the light of the publication of more archaeobotanical assemblages. The first important point is that most of the sites seem to have had barley cultivation immediately adjacent to the settlement. No single soil condition was favoured, but light free-draining soils were recurrently indicated from arable weed seeds. More marginal acidic and damp areas were also indicated, but usually on the later sites with significant quantities of oat. As suggested by Bond *et al.* (forth. a & b), this may represent the beginnings of the infield / outfield system, with the barley grown in the core area for thousands of years followed by the expansion of oat cultivation into the hinterland areas, generally in the mid to late first millennium AD. Soil amendment of this core area seems to be routinely undertaken, through the input of dung, midden material, seaweed, seaweed ash and sometimes turf. Rotation is also possibly indicated as fallow grass could be used for grazing, incorporating more dung into the soil system. Culm bases and low-lying weed seeds are common across nearly all of the assemblages that may indicate up-rooting as a harvesting strategy. This would be easy in light, sandy soils and would maximise the straw yield. However, caution in interpretation must be exercised as some of the wild components, especially the culm bases, could have been introduced from turf fuel. Most of the initial crop-processing stages were undertaken away from vicinity of domestic hearths, probably near to the fields themselves. Therefore, most of the cereal remains stem from accidents in final processing stages adjacent to the domestic hearth or cooking accidents, though certain rare deposits, such as conflagration deposits, provide evidence for the earlier stages as well. These deposits are particularly important for analysing agricultural practice, due to the relative lack of mixing with other plant material from different activities. A few sites suggest storage of barley in the ear form, but this is hard to verify as a consistent strategy due to the generally poor preservation of most of the assemblages.

8.2.3 Intensification and extensification of the arable economy

General

One of the more interesting points to have come from the survey of the evidence in Atlantic Scotland is the changing nature and diversification of the arable base that occurred in the region throughout the first millennium AD. Bond *et al.* (forth. a & b) recently suggested that the on and off site evidence from Old Scatness suggested intensification of arable production occurring during this time. The hypothesis was based on the species diversification and steady increase in the amount of cereal grain on the site and the increasingly intensive amendment strategies being undertaken in the adjacent 'infield' used largely for arable cultivation. It was therefore decided to test this hypothesis on a wider regional level from the archaeobotanical assemblages from domestic sites throughout the Western Isles. The sites to be used in this exercise included the seven non-funerary sites investigated in this study. The assemblages for the other four sites were either published, in the case of Dun Vulan in South Uist (Smith, 1999) and Allt Chrisal in Barra (Smith, 2000), or are still to be published in the case of Barvas in Lewis (Dickson, unpubl.) and Kildonan III in South Uist (Grinter & Valamonti, unpubl.).

Methodology

The assemblages from the eleven sites were split into 25 chronological blocks (see Table 6.1), following the broad dating scheme outlined in Section 4.2.4. This broad chronological grouping has been undertaken due to the difficulties and vagaries in dating in Atlantic Scotland and also to take into account the chronological resolution needed when proposing changes in economy over a millennium. Prior to a regional synthesis of this type it was necessary to standardise the data to ensure inter-site comparability. This standardisation followed the two basic steps outlined in Chapter 3. The first stage involved the acceptance or rejection of samples based on generic context type. Those samples included in the analysis were from contexts that represent probable occupation within the life cycle of a house, as defined by LaMotta & Schiffer (1999), including the hearth fills, ash spreads, floor levels and middens. Again, context types rejected included deposits that could have an unquantifiable amount of redeposition of material, such as foundation deposits and wall fills, or were difficult to phase in terms of discard, such as structural fills or rubble. The second stage involved the removal of samples with less than 10 Quantifiable Components as it was hard for the archaeobotanical coherence of these samples to be assessed.

The two basic parameters calculated for every sample, block and period that underpin this analysis were the grain concentration and number of deposits with significant numbers of grain within them. The grain concentration was standardised for each sample by calculating the number of grains per litre of sediment sampled. An average grain/litre was then calculated for each block and period. A Grain Cache Index represented the number of samples within the block or period that contained over 200 grains. 200 was chosen as it represented a significant amount that was more likely to be carbonised under crop-processing accidents or charring of a stored product rather than a casual cooking accident. This threshold value was first calculated by multiplying the grain/litre of the sample by 14, the volume of a single bucket of deposit that was close to the average of the volumes taken from all of the samples in the analysis. The resulting Grain Cache Index was then expressed as a percentage of the samples total for each period.

Results

Three main strands of evidence for the intensification and extensification are presented. Firstly, the cereal concentration and Grain Cache Index for each period is discussed and then the diversification in terms of cereal types grown on a block by block basis is presented for the whole of the Western Isles. Finally, pollen evidence for arable intensification from selected sites across the Western Isles is also reviewed.

Figure 8.1 presents the average grain/litre for each of the periods. There is a consistent increase in the grain concentration, with the most significant increase occurring between the Early to Mid Iron Age and in the second period of the Late Iron Age. This increase is also shown in the Grain Cache Index (Figure 8.2), though not as consistently as in the grain concentration graph. The graph demonstrates that by the Norse / Early Medieval period almost 20% of the generic occupation horizons from the three chronological blocks of Norse date contained over 200 carbonised cereal grains within a standardised bucket of sediment. It is argued that this significant increase in cereal grain concentration reflects a greater volume of grain on the domestic sites that may in turn reflect a surplus of grain following intensification. It is also interesting to note that by the mid to late first millennium AD throughout the Western Isles and the wider region, hulled barley is the almost exclusive variety, especially in those areas such as Orkney, where the naked form is phased out. This may be a function of climate but may also reflect the advantage that hulled barley has over the naked variety for storage. Hulled barley may therefore have been preferentially cultivated to fit in with the increasingly common practice of storing the grain product, an important component in intensive agricultural systems.

Figure 8.3 presents the proportions of identifiable cultivated genera from each site block with at least 10 identifiable cultivated seeds/grain, whilst Figure 8.4 presents the Ubiquity scores for each identifiable cultivated genera from each site block with at least 10 samples (see Table 8.7). The blocks are arranged in chronological order from the Early Iron Age on the left to the Norse / Early Medieval on the right. The key point to note on this graph is the appearance of significant quantities of flax and oat in the latter half of the first millennium AD following the 'barley monoculture' of the previous centuries and millennium. Flax seems to vary in its uptake, with certain chronological blocks, such as the LIA II block from Bostadh having a relatively high proportion of flax, whilst the later Norse block from the same site has only a small proportion of flax. This may represent different human groups incorporating flax into their economy, which may reflect access to land where flax grows best, such as the machair, or perhaps reflects different levels of society having access to the seed or processing equipment for the fibre or oil. A much more consistent signal is shown by the oat proportions, with the first significant use of oat within the second Late Iron period and between 20 and 30 % of the grain recovered identified as oat by the Norse / early Medieval period. Oat cultivation marks an important shift in the arable economy, as oat can grow in marginal areas where barley struggles and so may reflect the cultivation of areas previously only used for rough pasture, a process of *extensification* rather than intensification.

The final line of evidence is the first appearance of significant levels of cereal pollen in certain pollen profiles from across the Western Isles. Figure 8.5 presents the proportion of cereal pollen from Little Loch Roag in West Lewis (Birks & Madsen, 1979) and represents approximately 5% of the total pollen from the mid first through to the early second millennium AD. This is a significant influx of cereal pollen from the catchment, due to the nature of pollen taphonomy, and marks the first time this occurred in this diagram. The mid first millennium AD appearance of significant proportions of cereal pollen for the first time is mirrored in a number of other profiles across the Western Isles, including Loch a'Phuinnd in Lewis (Fossit, 1996) and Loch Lang in South Uist (Bennett *et al.*, 1990). The increase represents both intensification and the amount of land under cereal cultivation.

Models of explanation

How can these strands of evidence be interpreted? A number of models of explanation are possible. The first concept is that these lines of evidence are not showing arable intensification at all, rather they are a function of the taphonomy and methodology of the exercise. The taphonomic objection concerns how the archaeobotanical data, in the form of cereal grain, becomes carbonised and incorporated into the site. The increase in grain concentration and number of caches may relate to changing practises in the way that the crop is processed. For example, Fenton (1982), in his ethnoarchaeological observation of rural life in the recent past in the Northern Isles, described a process called 'graddening' by which the hulled material from barley was removed by slight charring and then gently grinding the glume off. It may be that this process became more common towards the end of the first millennium AD accounting for the increased number of burnt grain in 'graddening' accidents.

The methodological objection concerns the variability that is displayed between the cereal concentrations of different Mid Iron Age sites. For example, the values from the Dun Vulan midden are much higher than those measured from the wheelhouses sites, such as Kildonan III, which are in turn higher than some sites, such as Allt Chrisal and Guinnerso that have very low concentrations from their generic occupation levels. When the samples are grouped together a lower average is obtained than that for the later sites which have a much more consistent higher concentration of grain in their assemblages. However, these first two objections do not take into account the diversification of the crops grown and the regional pollen increase and so a number of models will now be explored that may explain why the possible intensification and extensification may have occurred. These include:

1. Increased sophistication in production, processing and storage.
2. Increase in population.
3. Production of surplus for trade, beer or fodder.
4. Change of emphasis in the agricultural economy.
5. The provision of buffering mechanisms.

The first model involves the ability of the human groups to grow and process greater volumes of grain. This can include the use of more efficient agricultural equipment, such as the mould board on the plough and the rotary quern and also advances in the use of iron, such as the use of iron ploughshares. The significant increase in the use of iron in the more prosaic tools in Scotland is generally seen as a post-Roman phenomenon (Hunter, pers. comm.), that fits in well with the time scheme. It has been argued above that the dominance of hulled barley at this time may reflect its storage qualities. There is also evidence of a more organised and centralised processing of grain in the Norse periods with the discovery of horizontal mills, such as the one excavated at Earl's Bu in Orkney (Batey & Morris, 1992). All of these advances would contribute to a greater efficiency in crop production and processing that would allow greater quantities of cereal to be grown.

The other models explain why the basic need for arable intensification arose. The first and most obvious explanation is a simple increase in population that would require more food for subsistence. However, gauging population increase in the archaeological record is fraught with difficulty and Atlantic Scotland is no different in that respect. Alternatively, the intensification may reflect a desire to create an arable surplus for trade in the forms of cleaned grain, beer or even fodder. The production of fodder is an important point to consider especially when viewing the diversification into oat that was used in Medieval Scotland for both food and fodder (Dickson, & Dickson, 2000).

The two models that might best explain the intensification are a basic change in the agricultural economy and also the provision of a buffering mechanism, against fluctuating climatic and social conditions within a marginal area. The basic change in the economy would involve the subtle but significant change from a largely pastoral economy to a more mixed agricultural approach. Again, this is notoriously difficult to spot from the material remains alone but possible future ways to test this hypothesis may be through the isotopic composition of the teeth and bones of the Iron Age and Norse people themselves (cf. Neighbour *et al.*, in press). The final model involves the explicit desire by human groups across Atlantic Scotland to diversify away from the barley monoculture practised for millennia before, in an attempt to provide a buffer mechanism against bad harvests and climatic downturns. It is interesting to note that the presence of ice bergs floating 100 km off the Irish coast proposed by Bond *et al.* (1997) would have appeared during the very time when the intensification of the later Iron Age is occurring. Of particular interest in regard to climatic downturns is the growth of oat that can grow in much more marginal land and climate than barley.

Wider significance

To summarise, the complementary picture shown by the grain concentration, cereal diversification and regional pollen signal, coupled with similar patterns of evidence from the Northern Isles, suggests a significant intensification and extensification of arable production occurred in the mid to late first millennium AD in certain parts of Atlantic Scotland. The reasons for this intensification are not obvious but it interesting to note that a similar intensification was proposed by van der Veen (1992) from her analysis of several Romano-British archaeobotanical assemblages in North East England. van der Veen & O'Connor (1998) went on to suggest that this intensification occurred for both arable and pastoral economies across lowland Britain in the wider British Late Iron Age and Roman periods. Several researchers (Watkins, 1980; Barclay, 1980; Armit & Ralston, 1997; Armit, 1999) have also proposed an arable intensification during this period in the fertile areas of the North-East and Tyne/Forth zones of Iron Age Scotland (after Piggott, 1966), judging by the large increase in settlements and souterrains for grain storage. The arable intensification proposed for Atlantic Scotland may reflect a similar conversion to a more mixed style of economy than the conventional system of the 'Celtic cowboys' of the British Iron Age. However, rather than interpreting this later change as reflecting the peripheral nature of Atlantic Scotland it may instead be reflecting the wealth of resources that existed here in the Mid Iron Age. Intensification and extensification was only required later to cope with the external or internal stimuli and pressures on the agricultural system that had forced the change in lowland Britain a few centuries earlier.

8.3 Wood and timber procurement

8.3.1 General

This section reviews the evidence for wood and timber procurement from the archaeobotanical data set compiled for Atlantic Scotland. The evidence for wood and timber was slightly different in nature to the cultivated remains as a much higher proportion of the material came from hand-retrieved samples taken throughout the 20th century. Most of the identifications were charcoal with uncarbonised wood fragments only recovered from a Late Iron Age II ditch in Iona (Barber, 1981) and Early Iron Age waterlogged deposits from Dun Vulan in South Uist (Taylor, 1999). Also, roundwood was very rarely identified separately that meant most genera / species identification was noted in the timber columns, leading to clear over-representation for timber components. Finally, few of the sites where detailed sampling for plant macrofossils was undertaken seemed to have matching systematic identification procedures for the charcoal, with most charcoal reports consisting of fewer samples chosen during the post-excavation analysis. Therefore, the regional synthesis and comparison is more tentative than those proposed for the arable components above. Nevertheless, regional patterns seem to be emerging from the data set.

One of the key points is the lack of any discernible chronological differences, which is in contrast to the patterns observed for the arable economy. Therefore, Ubiquity counts of the different genera / species from all the periods from each area have been calculated (Table 8.9). The basic sample population was the number of blocks with charcoal remains from each area. Two levels of Ubiquity were calculated for the genera / species, the first level recording the basic Ubiquity and the second recording the number of sites with abundant remains, either recorded as abundant on the qualitative scale or had a Ubiquity score of greater than 50% for blocks with greater than 10 samples.

8.3.2 Shetland

13 blocks contained charcoal from the Early Iron Age through to Norse periods (Table 8.3). 15 different genera / species were recovered with most of the charcoal undifferentiated between roundwood and timber. The most common and abundant remains were Ling heather roundwood. This represents the use of a very common resource in the area throughout the first millennia and reflects both deliberate gathering and perhaps some contamination from peaty turf used as the fuel. The second largest group of remains stemmed from coniferous genera, including spruce, pine, larch and fir. Almost all of these exotic genera were likely to be driftwood, though small amounts of pine may have been locally available. A surprisingly high presence of deciduous genera was also noted, including alder, birch, hazel, ash, Pomoideae undifferentiated, oak, willow, rowan type and elm. The presence of oak, ash and elm are particularly surprising, as these species were almost certainly not growing in the area at this time (Bennett *et al.* 1992, 1997). This may reflect further gathering of driftwood stemming from the North Sea and mainland Scotland, accidental burning of material from objects made on the mainland or even limited trade of the timber itself. The other deciduous species could have grown in very sheltered positions away from grazing animals, such as on small islands in lochs or on cliffs.

8.3.3 Orkney

19 blocks contained charcoal from the Early Iron Age through to Norse periods (Table 8.4). A surprisingly diverse range of genera / species was recovered, with 16 types recorded. Again, the most common and abundant remains were Ling heather roundwood. Also, birch and willow were repeatedly recovered, suggesting limited local growth. Coniferous timber was well represented, including common occurrences of spruce, significant quantities of pine and some larch. Again, this almost certainly represents the harvesting of driftwood, though some of the pine may have been local. Other deciduous types included significant quantities of alder, hazel, ash, oak and rowan type and single occurrences of poplar / aspen, *Prunus* sp. and elm. Roundwood of alder, juniper, ivy and willow suggest a local derivation for these species, that again may have grown in secluded and sheltered areas (Bennett *et al.*, 1997). However, it unlikely that the oak, ash and elm were growing locally and so represent the same procurement pathways as cited for Shetland above.

8.3.4 Caithness and Sutherland

9 blocks contained charcoal from the Early Iron Age through to the Norse periods (Table 8.5). A relatively low range of genera / species was recovered, potentially at odds with conventional wisdom that would suggest a greater diversity of wood available on the mainland. However, this low number is almost certainly a function of the low number of blocks, over half of which were sampled by hand retrieval, compared to the greater number of site blocks systematically bulk sampled in the Northern Isles.

Heather was present in much lower numbers than in the Northern Isles and the largest group of remains stemmed from deciduous timber. This included significant quantities of alder, birch, hazel, oak and willow, with a single occurrence of Rowan type. This represents the main components of a northerly mixed forest that could have been growing in the area, though not necessarily in the 'flow-lands' of the north-east (Charman, 1994). The lower quantities of heather may reflect the relative expanse and availability of heath and moorland compared to the Northern Isles and increased use of wood as a fuel, preventing the fuel contamination pathway for heather fragments. Proportionally less coniferous roundwood and timber was also recovered, including conifer type, juniper and pine that could have been growing in the region. Therefore, it is possible to suggest that driftwood played less of a part in the timber procurement than in the Northern and Western Isles during this period.

8.3.5 Argyll, Inner Hebrides and Skye

11 blocks contained charcoal and a single Late Iron Age II block from Iona contained uncarbonised wood remains (Table 8.6). 16 different genera / species were recorded from the area. Roundwood was better represented, though this reflects the improved level of recording of some of the reports as much as local woodland growth. This roundwood reflected a diverse mixed forest, with alder, birch, hazel, ash, holly, oak, willow and Rowan type recovered. Ling heather was also identified, but again not in the same quantities as the Northern and Western Isles. The deciduous timber also reflected a diverse range of woodland types, with significant quantities of hazel, oak, willow, birch and alder, some ash and single find spots of Pomoideae undifferentiated and elm. The waterlogged remains in the Late Iron Age II ditch from Iona contained thousands of fragments of roundwood and timber from wood-working of deciduous species, including debris, rough-outs and some finished wooden objects (Barber, 1981; Fairweather, 1981). The wood was almost certainly obtained from a local resource, though not necessarily from the island but certainly from the adjacent mainland. Relatively small quantities of coniferous timber were found across the area in comparison, including some conifer type, spruce and pine. The spruce would certainly have been gathered as driftwood, though the pine could have been locally derived.

8.3.6 A question of timber supply

This brief review of the evidence of largely charcoal remains from across Atlantic Scotland in the first millennia has highlighted a few regional variations. In general, heather and coniferous timber are the most common types in the Northern and Western Isles, with lesser proportions of deciduous material. The heather would have derived from deliberate gathering for various uses, such as kindling, furnishings, bedding and basking-making. It could also have been introduced through the use of peaty turf and peat as fuel, as demonstrated from the soil micromorphology of ash in Scalloway, Shetland (Carter, 1998b) and St. Boniface, Orkney (Carter, 1998a, 1999). The conifers were largely driftwood derived, though pine may have been locally managed on a small-scale. Some of the deciduous material could also have grown, or even be managed, in certain sheltered and inaccessible areas. However, it is also possible that some of this material was driftwood derived and a small proportion perhaps even traded with the mainland, as part of objects or as timber in its own right. The assemblages from the mainland show a slightly different pattern with less heather and conifer timber and more deciduous roundwood and timber. This perhaps reflects a greater reliance on the regionally available mixed-forest than the opportunistic gathering and small-scale management proposed for the Northern and Western Isles.

However, the biggest problem with the data set reviewed is the lack of certainty over the specific use and derivation of the remains. This again stems from the taphonomic model of carbonisation in the domestic hearth that mixes plant material from an unknown number of human activities and behaviour. However, as argued before the conflagration layer from Dun Bharabhat demonstrates the increased level of archaeological and archaeobotanical interpretation possible from conflagrations. For example, when considering the question of timber procurement for structural remains it was possible to identify that spruce and pine timbers were used for this purpose and that the pine at least may have come from a locally managed resource (see Section 6.3.5). Therefore, the best deposits to address the question of structural timber supply are those *in situ* burnt levels remaining from conflagrations or waterlogged timber remains. A review of the literature relating to the Atlantic Scottish Iron Age highlights the surprising infrequency of such deposits (see Table 8.10). This is probably a product of a number of factors including archaeological recognition, climatic constraints and site formation and erosion processes.

The conflagration at Scalloway (Sharples, 1998) marked the end of the primary occupation of the complex Atlantic roundhouse. It was recognised archaeologically through the widespread evidence of interleaved ash and charcoal. Soil micromorphological analysis (Carter, 1998b) suggested that this 'red ash layer' represented not the remains of the roof as first thought but rather the burnt remains of the organic floor material built up during the final period of occupation. The roof material itself was thought to have either burnt away completely or was removed, as a deliberate action or as a product of the re-occupation.

The extensive excavations at the Howe, Orkney (Ballin-Smith, 1994) uncovered the highest frequency of conflagrations at a single site. The fires occurred in both secondary occupation levels within the broch and also at different points of the Mid Iron Age external occupation. Detailed sampling and archaeobotanical analysis (Dickson, 1994) of these conflagrations provided a wealth of information on the plant materials used in the structure. Across the site, the structural timbers were a mix of willow and spruce, with the willow of probable local derivation and the spruce from driftwood. Little explanation is given for the cause of the fires except for the conflagration in the rampart cells of the NW building (Ballin-Smith 1994, 67). This may represent a deliberate firing of the cell roofs as part of a closure episode as the fire was prevented from spreading into the main house and the cells then fell out of use for the remainder of the period.

Turning to the Western Isles, recent excavations at Bornais, South Uist (Sharples, 2000) have revealed a conflagration horizon of a probable wheelhouse. This was replaced by a rectilinear structure. Archaeobotanical research, including the analysis of several burnt timber planks, is on-going. Further structural information was also recovered at the excavations at Loch na Beirgh, Lewis (Harding & Gilmour, 2000), preserved by the waterlogged conditions of the lowest excavated levels, rather than by carbonisation. A coppiced hazel screen and a single spruce post have so far been examined (Church, forth.). Further south, woodworking debris from a waterlogged Early Iron Age context at Dun Vulan (Taylor, 1999) contained hazel, alder and larch chippings. Again, the larch would have been collected as driftwood, attested by the presence of shipworm boreholes, and one of the hazel pieces displayed the characteristic disarticulation heel of coppicing, known as a coppiced heel. The larch chippings stemmed from a trunk of timber, that could have been split to provide relatively large quantities of wood.

Research in the Inner Hebrides has also produced two sites with conflagrations, both excavated by MacKie. At Dun Mor Vaul, Tiree (MacKie, 1974) excavations revealed ephemeral evidence of a conflagration of an Early Iron Age structure underlying the main complex Atlantic roundhouse, including a cache of burnt barley grain (Renfrew, 1974) and an *in situ* carbonised post of unknown type. The conflagration at Dun Ardtreck was much more substantial, with a thick layer of charcoal and ash across much of the site interpreted as a major structural fire (MacKie, 2000b). The partial excavation of a 'vitrified dun' at Langwell in Sutherland also revealed the extensive remains of a major structural fire, including what appears to be several radially orientated roofing timbers (Nisbet, 1995). Unfortunately, no identifications were made of the remains. Further south, oak branchwood was identified from a souterrain roof fire from Cyderhall at the southern limit of Atlantic Scotland (Boardman, 1992).

A number of important points are raised by this brief review. Firstly, there is a recurring theme in the way that these fires signal the end of a period of occupation on the site. Many of these conflagration deposits are usually followed by a period of abandonment, sometimes signalling the final major archaeological episode on the site, as at Dun Bharabhat and Langwell. The other sites that continue to be occupied or re-occupied at a later date all display major structural or spatial re-organisation, for example at Scalloway, Bornais and the Howe of Howe. The conflagration could also mark a deliberate action to clear or 'cleanse' the site prior to re-occupation. Therefore, these conflagrations, no matter what their cause, mark major changes in the way these sites are used, viewed or lived in by their occupants i.e. an episode of closure or re-birth in the life-history of the structure.

As argued above, it is probable that timber within these deposits was specifically chosen for some form of structural component of the building. This provides us with information on the type of tree or shrub used and its likely source within the wider economic landscape. This issue of timber procurement is seen as an important economic consideration throughout Iron Age Atlantic Scotland (Fojut, forth.), with some researchers viewing timber availability as a possible stimulus for social and structural change (cf. wheelhouses Armit 1992, 1996). From the direct evidence from conflagrations and waterlogged remains, in the Northern and Western Isles timber procurement was based upon the gathering of driftwood, such as spruce, and the use of smaller timbers of species that could have been obtained locally, such as willow and hazel. Indeed, it has been argued from the preliminary analysis of hazel wattlework from Loch na Beirgh that the remains stemmed from a local, coppiced woodland. This pattern of procurement does not require large-scale trade networks of timber and the consequent trade deficits that would result on an island – mainland axis. However, none of the evidence directly relates to the super-structures of the Atlantic roundhouses, the monument theoretically requiring the greatest volume of timber. Instead the evidence is derived from a wheelhouse (Bornais) and smaller cellular units within a) the shell of abandoned roundhouses (e.g. Dun Bharabhat) or b) external to the roundhouses at their time of occupation (e.g. Howe of Howe). Hence, timber procurement within the Mid Iron Age (the *floruit* of complex Atlantic roundhouses) may have required a trade in timber. The likely presence of *in situ* substantial timber remains from the primary and secondary roundhouses at Loch na Beirgh represents a unique opportunity to address this important issue in detail. Other site types, such as vitrified forts (e.g. Rahoy, Argyll; Childe & Thorneycroft, 1938) and waterlogged sites, such as the external structure at Dun Bharabhat, are also important site types to address this question of timber procurement.

8.4 Future research directions

8.4.1 General

This final section outlines future avenues for research into the anthropogenic use of plants in Atlantic Scotland. Four main areas are explored including the development of a regional approach to sampling, further programmes of experimental archaeology, addressing the problem of taphonomy and finally developing wider approaches in an attempt to gain as much interpretative value from the regional data set as possible.

8.4.2 Regional approach to sampling

The regional sampling strategy outlined in Section 3.2 had a number of strengths and weaknesses. One of the main problems was the subjectivity involved with the initial site selection. As all of the sites were chosen by archaeologists to answer research questions or in response to erosion / destruction of the site, this meant that theoretically the sites sampled were not statistically representative of the site population. It may however be possible to choose sites types, such as those revealed through coastal erosion or as nodes in the landscape, through *random* sampling, establishing statistical representation from the start. The excavation and sampling methodology developed at Galson demonstrated the interpretative value for archaeobotany from bulk and mineral magnetic sampling of a vanishing coastal erosion resource without recourse to full excavation. This sort of sampling could be utilised on a *random* basis for a number of sites located through coastal erosion surveys throughout the Western Isles (cf. Burgess *et al.*, 1997a; Church & Burgess, in press) and beyond, minimising expenditure but maximising archaeobotanical interpretation. Another interpretative bonus from the regional sampling strategy was the exciting discovery of different site types found at Gob Eirer, An Dunan and Guinnerso through the targeting of sites identified through survey that are not usually excavated in Atlantic Scotland. Similar excavation campaigns would expand the settlement record beyond the broch and post broch complexes that have dominated the published literature.

The *interval* sampling of the final 'floor level' at Bostadh represents a new approach at integrating environmental and archaeological techniques to understand detailed human behaviour on a site scale. The SEARCH campaign in South Uist has developed this technique further, with a number of different sites having been sampled in this way (cf. Parker-Pearson *et al.*, 2001). It is hoped that comparison of these sampling exercises from sites of different ages will allow issues of continuity and change in the use of domestic space to be addressed, which will in turn reflect wider dynamics of the social landscape (Smith *et al.*, 2001).

The final issue stemming from the regional sampling approach is the comparability between the various research campaigns. *Total* sampling is now routinely employed within most research projects that provides the opportunity for direct statistical comparison of the site assemblages. However, for *total* sampling to still be possible in times of increased financial pressure, initial standardisation phases should be included in the post-excavation process by which those deposits, such as unreliable contexts or samples with few plant remains, are excluded from further processing or analysis. In this way, time and therefore money can be directed to those samples with the most interpretative value.

8.4.3 Experimentation

The hearth experiments outlined in Chapter 5 highlight the interpretative value of hypothetical-deductive experimentation. The research outlined in that chapter presents a pilot study into the viability of using proxy geoarchaeological techniques to assess aspects of archaeobotanical taphonomy. The pilot study was successful as it highlighted the mineral magnetic and archaeobotanical differences between certain fuel sources. Soil micromorphological analysis also demonstrated the different soil micro structures for each of the fuels (Tams, forth.). Therefore, it is proposed that a much more detailed experimental project would have far-reaching interpretative value for archaeobotanical taphonomy and fuel procurement strategies. This project could include the following avenues for experimentation;

1. More fuel varieties needed including different types of turf, peat, dung and organic soils, such as estuarine sediments.
2. More hearth runs of the various fuel types needed to establish full range and concentrations of plant macrofossils introduced by each source.
3. Introduce improved techniques into experimentation including detailed measurements of different parameters, such as the amount of fuel consumed and the temperature variability in different parts of the fire (cf. Linford & Canti, 2001).
4. Improve sampling procedures with interval sampling in plan to assess optimum zone for carbonisation.
5. Heather burning of different ages to assess the variability in the proxy records and also to assess the variability of ring counts for different age profiles of heather (see Section 7.4.2)
6. Well-humified peat could be burnt from different areas and the variability assessed in terms of mineral magnetism, archaeobotany and phytolith content. Phytolith content seems to vary between sources very markedly (Westoby, 2001), allowing statistical separation. Issues of continuity and change in the localised areas of extraction for well-humified peat could then be assessed, as suggested for the sites from the Bhaltos peninsula in the Mid to Late Iron Age (see Section 7.5).
7. Establishing similar experimental projects in other island zones. Initial experimentation using the same mineral magnetic methodology outlined by Peters *et al.* (2001) at Old Scatness Shetland (Dewar, 2000; Church *et al.*, forth.) has shown a much wider variability in the discriminant analysis for ash, a function of fuel selection or underlying geology. Therefore, to establish the sources used, local fuels will need to be burnt and a new discriminant analysis undertaken. A wider regional appreciation of archaeobotanical taphonomy and fuel procurement strategies would then be possible.

Another aspect of this experimentation could be the observation of the way the different fuels burn within the interior of the replica 'figure-of-eight' house at Bostadh, constructed in 1999 adjacent to the excavation (Neighbour & Crawford, 2001). The assumption that repeated use and clearing of the central hearth creates a magnetic signal of repeated spatial use in the house could also be tested. The experimentation would involve repeated fire hearth runs followed by clearance and removal of the ash outside using the only doorway. In this way, small amounts of ash would be introduced into the floor and distributed by the visitor access around the structure. Detailed interval sampling of the floor level would then be used to assess the spread of this ash and compare the patterns to the most common route around the structure.

The final aspect of experimentation could involve the use of Calanais farm for the testing of the various yields and weed affinities of the barley, flax and oat crops. A single season of six-row hulled barley cultivation was undertaken in 1986 (Harding & Topping, 1986) that illustrated the interpretative value of such an exercise in terms of crop yield and weed associations. Different cultivation practises and the yields and habits of different varieties and species could also be tested. For example, the strengths and weaknesses of two-row hulled barley could be tested against the six-row species to try and understand the presence of two-row barley in the first millennia in West Lewis.

8.4.4 Addressing the problem of taphonomy

The hearth experiments outlined in Chapter 5 were undertaken primarily to elucidate aspects of archaeobotanical taphonomy. The key research problem involved the disentangling of the processes that led to the mixing of mutually exclusive cultivated and wild components in a typical sample from an occupation horizon in Atlantic Scotland. The level and character of archaeobotanical contamination from the most common fuel types was highlighted but the basic research problem still remained unanswered. It was concluded that an unknown number of mixing episodes, both natural and human, *prior* to carbonisation in the hearth could also account for the admixtures sampled. It has been argued that the research problem is basically unanswerable for most of these context types and so the level of detail of the research questions asked must reflect this taphonomic uncertainty from much of the data set. However, it has also been argued that certain deposits may overcome this problem due to their unusual formation processes. The first set of deposits that could be examined are those that are waterlogged. The taphonomy of these deposits avoids the mixing prior to and within the hearth. Also, *in situ* uncarbonised structural remains and deposits, such as those uncovered in the final days of excavation at Loch na Beirgh, provide direct evidence for the types of wood and material used for the construction of the buildings. However, waterlogged remains also have different taphonomic problems and issues of mixing, as demonstrated by an initial assessment of a few bulk waterlogged samples from Dun Bharabhat (Millar, 2002). It has been argued that conflagration deposits can also overcome the problem of taphonomic mixing, especially with regards to the use and procurement of different wood types for structural remains. A number of published site reports have highlighted possible conflagration deposits that have not been analysed or sampled in any detail, such as the Atlantic roundhouses at Dun Ardtreck and Langwell (see Table 8.10). Sections through the burnt remains still exist at both sites and so detailed sampling exercises from these sections may well recover very useful archaeobotanical information without extensive and therefore expensive excavation.

8.4.5 Wider interpretative approaches

The final area for future research is the way the ever-expanding archaeobotanical database in Atlantic Scotland is compared and synthesised. The review of the evidence above in this chapter has highlighted the interpretative value of detailed charcoal analysis that has only been undertaken routinely on sites in the past decade. Also, the review highlighted the inadequacies of the data recording, especially when differentiating between roundwood and timber that provides important information in assessing the taphonomy of the remains (see Section 7.3). Hardly any of the published reports contained ring count data for the roundwood. The ring counts from the heather remains in Section 7.4.2 demonstrates the interpretative value of such an approach and areas with abundant heather charcoal, such as Shetland, may benefit from this methodology.

The review above was based only on material from published data but a more concerted synthesis referring to detailed reports archived in the NMRS and unpublished data from individual archaeobotanists would greatly improve the resolution and detail of the data set. A number of research themes and hypotheses could be tested using this more detailed data, including the testing of the intensification model for the first millennia across Atlantic Scotland as a whole. Also, the site variability in terms of both the total assemblage and specific parameters such as grain concentration could be compared across time, space and site type. Again triangular diagrams could be used to try and identify specific assemblage profiles to site types (see Section 6.4), which moves 'archaeobotany beyond subsistence' and into the wider questions of the social and economic landscape.

There is also a need to try and integrate evidence from different regions on a national scale. For example, it was clear that the assemblages from the mainland in Caithness and Sutherland had affinities with the contemporary assemblages from areas such as Moray, Aberdeenshire and Angus as well as those in Atlantic Scotland. Again, a significant proportion of the plant macrofossil assemblages recovered over the past 20 years have been sampled for statistical representation (cf. van der Veen, 1992) that would allow direct quantitative, rather than qualitative, comparison. Therefore hypotheses based on basic statistical manipulation of the data, such as the intensification of the arable economy in the first millennia, could be tested on a national scale.

Chapter 9: Summary and conclusions

9.1 Introduction

This study has attempted to reconstruct elements of the anthropogenic use of plants in the Western Isles during the first millennia BC and AD. Much of the research has involved examination of the methodological, taphonomic and interpretative issues of archaeobotany in Atlantic Scotland, using West Lewis as a detailed case study. A number of research themes were introduced in the first chapter and this final chapter presents the summary accounts and conclusions for each theme. Six main themes were addressed including two essentially methodological areas of research concerning the sampling and the taphonomy of the archaeobotanical assemblages, and four interpretative themes including a) the social and ritual dimension of plant use, b) the reconstruction of the arable economy c) wood and timber procurement and d) the gathering of plants in key landscape zones.

9.2 A regional sampling strategy

One of the main research aims of this study was to establish a regional strategy for the investigation of the human/plant relationship, through the statistically valid inter-site comparison of nine archaeobotanical assemblages. The sites were excavated over a period of 13 years by a number of different researchers for two general reasons; either as part of a wider landscape research project or as a response to erosive threats to the site. The sites excavated included;

1. A Bronze Age kerb cairn within the wider ritual landscape at Calanais.
2. Gob Eirer, a promontory enclosure of Early Iron Age date.
3. Dun Bharabhat, a small complex Atlantic roundhouse and secondary occupation of Mid Iron Age date.
4. Cnip, a wheelhouse and secondary occupation also of Mid Iron Age date.
5. An Dunan, a small Mid Iron Age islet site of a probable funerary function.
6. Guinnerso, a small cellular complex of probable Mid Iron Age date, located within extensive blanket bog.
7. Loch na Beirgh, Late Iron Age secondary occupation of a large complex Atlantic roundhouse.
8. Galson, a series of Late Iron Age and Norse structures eroding from machair.
9. Bostadh, a complex of Late Iron Age and Norse structures excavated in advance of coastal erosion.

All of the sites excavated from 1995 onwards implemented a strategy of either *random* or *total* sampling of well-defined, sealed and undisturbed contexts. Two samples were taken; a bulk sample of between 14-28 litres for wet-sieving and a routine sample of approximately 0.25 litres, for mineral magnetic analysis. The integration of archaeobotanical and geoarchaeological techniques was undertaken to assess the taphonomy of the archaeobotanical assemblages. Detailed sampling methodologies were also employed to answer specific research questions regarding site formation processes. These included close-interval (2cm) sampling for mineral magnetic measurements from a number of sections through hearths and occupation levels at Galson and Guinnerso and interval sampling on a 0.2 m grid across the final occupation level of House 3 at Bostadh.

The samples were systematically processed using exactly the same equipment and calibration in terms of the mineral magnetic measurements. Certain samples were removed prior to analysis due to stratigraphic considerations and if the number of Quantifiable Components was less than 10. Two general groups of data formed the statistical basis of this study including the sample and the site block. The sample data was made up of two datasets from the charcoal and carbonised plant macrofossil identifications from the individual bulk samples. The site block data was the amalgamation of all the samples from a site phasing block, again resulting in a charcoal and macrofossil dataset for each block. The chronological resolution of the blocks was relatively broad due to the vagaries of absolute dating in the region.

9.3 The problem of taphonomy

The basic taphonomic research problem for Atlantic Scottish archaeobotany is the admixture of plant communities and habitats present in a typical sample from an occupation horizon. The range of plant species recovered would not usually grow together and so represent a complex process of taphonomy leading to the archaeological deposit. There is an implicit, but rarely stated, assumption within archaeobotanical reports from domestic structures in the region that most of the plant macrofossils become carbonised in the hearths and are then spread by various taphonomic pathways to the archaeological deposits that are sampled. However, this basic taphonomic model has not been demonstrated through an independent proxy record.

It is with this research problem in mind that mineral magnetic measurements were taken for each routine sample and profiles through key sections. In general, magnetic enhancement was observed throughout a range of archaeological deposits on each of the sites sampled. It is proposed that this magnetic enhancement in most context types stemmed from the spread of ash from hearths or other burning activities. The results indicated a clear correlation between magnetic enhancement, ash content and carbonised plant macrofossil concentration across the sites. A critical threshold in magnetic susceptibility, an approximate indication of ash content, was highlighted beyond which significant concentrations of plant macrofossils could be recovered.

A general model of archaeobotanical taphonomy can therefore be proposed for the seven essentially domestic and two probable funerary sites within the study area. Several *in situ* hearths were recovered from each of the domestic sites and the associated hearth material and adjacent ash spreads displayed marked magnetic enhancement with variable carbonised macrofossil concentrations. The subsequent spread of this ash, through various human, accidental or natural processes, was also demonstrated through magnetic enhancement of associated archaeological deposits, such as floor levels and middens. In this way, a large proportion of the macrofossils recovered from an archaeological phase would have ultimately been carbonised in the hearth(s) within the structure. These hearths acted as a carbonising point for plant material that become incorporated into the fire and ash, whether deliberately as kindling or fuel or accidentally through an unknown number of variable human and natural processes. The two funerary sites investigated also showed the correlation of magnetic enhancement, ash input and macrofossil concentration. However, it is likely that the ash in these would have been produced through potentially different burning episodes and processes than those occurring in a domestic hearth.

The consistently high proportion of superparamagnetic grains within the domain state profile of most of the samples suggested a similarity of burning process producing the ash. Therefore, a programme of experimental archaeology was designed to investigate the processes of carbonisation in replica hearths and the residues produced. Investigating the types of fuel used was seen as a key research theme for a number of reasons. Firstly, fuel procurement is an important research question within the study area in its own right. Secondly, the admixture of plant ecologies within typical archaeobotanical assemblages in Atlantic Scotland may be a function of contamination from the fuel used in the hearth. A basic research question was therefore developed with the primary aim of assessing the amount of contamination from different fuel sources and developing independent proxies to source the fuel. Proxy records independent of the archaeobotanical assemblage are needed to allow the separation of those plant macrofossils that could be fuel contamination from those macrofossils relating to other human behaviour. It was clear that mineral magnetism could be used as an independent proxy as there was demonstrable magnetic enhancement with ash on the archaeological sites within the study area.

Four main fuel types were used in the experimentation including Pine wood, well-humified peat, upper fibrous peat and peaty turf. Sourcing the fuel was successful through mineral magnetic analysis and clear variability, in terms of both concentration and composition, existed between the archaeobotanical remains introduced by the different peat fuels. Well-humified peat had very low concentrations of remains including indeterminate rhizomes, small culm bases and single seeds of Ling and sedge. However, the fibrous upper peat and peaty turf contained far greater numbers of culm nodes/bases and rhizomes and various carbonised seeds from acid loving plants present on the heath from where the peat and turf were cut. Application of the mineral magnetic sourcing techniques to archaeological ash samples from eight of the nine sites indicated that well-humified peat was the main fuel source throughout the first millennia in West Lewis, introducing only a limited amount of archaeobotanical material as fuel contamination. The samples from Calanais kerb cairn indicated the burning of peaty turf that introduced a much greater concentration and range of plant macrofossils from the fuel source than in the other sites examined. This was reflected in the composition of the archaeobotanical assemblage recovered from the cairn. The experimentation also demonstrated the high temperatures possible in a domestic hearth that introduces a large preservation bias during the carbonisation process.

It has been proposed that the admixture of plant remains in a typical sample does not relate to contamination from the fuel source. Rather, the mixing occurs from pre-carbonisation activity and within the hearth itself. Therefore, the basic research problem is unresolvable for most of the samples. Deposits exist where this taphonomic problem is overcome, including conflagrations or *in situ* waterlogged remains, but these are rare in the archaeological record. One such deposit was the set of contexts stemming from the conflagration of the roof in the secondary structure at Dun Bharabhat. Archaeobotanical material recovered from the layer included burnt timbers and a single sample of exceptionally well preserved barley straw. The interpretative value for archaeobotany from this level, compared to most of the samples from the rest of the area, was significantly higher in terms of arable agriculture and wood procurement strategies.

It is therefore important that the level of interpretation placed on this material is matched by the resolution of interpretation possible from such remains, bearing in mind the taphonomic complexity of the formation of the assemblage. For example, it is possible to identify different crop plants available and the range of possible gathered foodstuffs during archaeological phases but interpretation of more detailed crop-processing procedures and weed ecologies is fraught with difficulty if based largely on material from ash spreads, floors and middens. The appreciation of taphonomy guided the resolution and level of detail for the questions posed in the four interpretative research themes.

9.4 The social and ritual dimension of plant use

Through the comparison of the basic composition of the plant remains from the Mid Iron Age blocks, it has been possible to begin to assess aspects of the use of plants across a contemporary landscape. A wide diversity of activities relating to the use of plants seems to have occurred on the domestic sites. These sites probably represent the permanent homesteads where the products of the arable economy, including straw, chaff and grain, were routinely handled. Guinnerso and An Dunan represent sites within the wider economic and social landscape where more specialist activities were practised, with a concomitant reduction in the range and concentration of plant material carbonised. It has been argued that Guinnerso could represent a transhumance site for summer grazing where arable agriculture played a very minor part in the economy of the site with very few arable remains recovered.

An Dunan probably represents a funerary site, where aspects of the wider economic and social landscape were incorporated into the elaborate central hearth as part of structured deposition accompanying human cremation. A single piece of Purging buckthorn was found within the ash spreads from this hearth. This probably originated from hundreds of miles south in the Atlantic continuum, representing possible trade and exchange of exotic organic material. The incorporation of physical elements of the wider economic landscape was also apparent at the earlier funerary site at

Calanais kerb cairn, including arable products, fodder and other gathered plant material. There was also a continuum between the domestic sphere and belief systems in the Atlantic Scottish Iron Age, with organic structural components being invested with symbolic meaning as well as serving a utilitarian purpose. A number of case studies are presented to illustrate this point, including special foundation and closure deposits at Loch na Beirgh.

9.5 Reconstructing the arable economy

It is tempting at first to view the arable economy of the first millennia being dominated by a barley monoculture, with fields of identical crops being grown. On most sites across the region where further identification has been possible, the barley was identified as the hulled variety and the rachis internodes and ratio between symmetric:asymmetric grain indicating the six-row species. The evidence from this study supports this assertion of the dominance of six-row hulled barley but also hints at other types of barley being cultivated.

Detailed analysis of the large block assemblages from West Lewis indicated that the hulled and naked varieties and the two-row and six-row species were grown in the wider economic landscape at various points and proportions throughout the first millennia. Naked barley seems to have been grown in significant quantities only in the early to mid first millennium BC before being phased out by the almost exclusive cultivation of hulled barley. Six-row barley seems to be the dominant species but two-row was also grown in its own right. It is perhaps important to note that the highest proportion of two-row barley in the block assemblages came from the straw rich layer in the conflagration at Dun Bharabhat. Perhaps the species was specifically cultivated for straw production rather than just grain production, for use as thatch and internal furnishings or as fodder. This hints at a relatively sophisticated regime of cultivation within the landscape, with certain barley varieties and species grown for specific purposes.

A two-stage uptake of oat seems to have occurred in the first millennium AD that may indicate an initial experimentation during the Late Iron Age period followed by a more substantial and important contribution to the arable economy in the Norse period. The initial uptake may represent a need or desire for the diversification of the arable economy. It also expands the area of land that can be brought under cultivation, as oat can be grown within much more marginal areas than barley. Also, oat needs little tending of the crop during the growing season unlike barley that requires labour intensive cultivation practices, such as manuring, to maintain yields. The uptake of oat therefore involves an extensification of the arable economy into more marginal lands.

An expansion into flax cultivation also occurred in the latter part of the first millennium AD. However, the various quantities did not increase progressively over time like oat, indicating variable uptake of the crop from site to site. It is proposed that the flax was grown for the production of both seed and fibre, though this is difficult to verify from the remains. The cultivation and processing of both primary products, especially the fibre for cloth, required access to labour, economic reserves to sustain the settlement through the processing, special equipment and the necessary skills to undertake the final spinning and cloth making if these were undertaken on the site. Also, the inhabitants would need to have access to specialised trade networks if the processed fibres or cloth were to be traded or exchanged. Therefore, it is possible that those settlements undertaking flax cultivation were of a higher social standing than the norm, perhaps reflected by the non-linear uptake of the crop across the later blocks in this study.

Both wheat and rye were recovered in very low numbers and are likely to represent weeds of cultivation rather than cultivation in their own right. It is interesting to note that of the three blocks containing rye, two were Norse. Perhaps this reflected increased exchange of agricultural products, such as cereal seed, across Atlantic Scotland that would introduce slightly different weeds to the island.

Assessing wider agricultural practices was difficult due to the taphonomic mixing for many of the assemblages. However, the straw layer in the conflagration level in Dun Bharabhat indicated that the barley was probably grown in the machair in amended soil and was harvested by up-rooting to maximise the straw yield. Aspects of the assemblages from the other two sites in the Bhaltos peninsula were similar to indicator elements and taxa in the conflagration deposit, suggesting similar agricultural practices were in place for over 500 years in the local area. Uprooting and soil amendment, through the incorporation of dung and perhaps seaweed ash, was also suggested from the other domestic sites.

9.6 Wood and timber procurement

It is proposed that the wood and timber supply for most of the sites seems to stem from two main sources. Locally derived deciduous roundwood and branchwood was used for internal furnishings and other uses, such as basket weaving. Timber was obtained from locally derived pine and from driftwood of pine and various exotic genera. The local material may have consisted of managed copses in sheltered valleys, of pine and hazel for example, and opportunistic exploitation of bushes / small trees in places inaccessible to grazing animals, such as islands in lochs and cliffs. Also, there are slight hints at mainland derived material from the occasional recovery of oak and ash fragments, though this is at best tentative. However, the site types from which the evidence stems do not include the monumental Atlantic roundhouses of the Mid Iron Age. Indeed, many of the structural configurations imply a move to conserve timber for roofing, for example the wheelhouse and cellular architecture. Whether the Mid Iron Age Atlantic roundhouse *floruit* required a trade in timber or was based on a mix of driftwood and locally derived wood is hard to resolve from the present knowledge. However, the conflagration from Dun Bharabhat of the secondary roundhouse only slightly smaller than the original Atlantic roundhouse dates within the broad period of the Mid Iron Age and so may hint at local procurement for the smaller monumental structures.

9.7 The gathering of plant material

The third main interpretative research theme assessed the contribution of gathered plants to the economy of the first millennia from three main zones within the landscape including the moorland, seashore and woodland. A number of resources were taken from the moorland including various types of peat, heather (*Erica/Calluna* spp.), berried plants and sedges. To extract peat from areas of blanket bog required planning, social organisation, equipment and systems of land control. Management or selective gathering of the heather resource was also apparent in the Mid to Late Iron Age. The management may have involved the use of fire to systematically regenerate the heather shoots. Seeds from a range of berries plants, including Bearberry (*Arctostaphylos uva-ursi* L. Sprengel), Bilberry (*Vaccinium myrtillus* L.), Cowberry (*Vaccinium vitis-idaea* L.) and Crowberry (*Empetrum nigrum* L.). were recovered from a number of the sites with the possible transhumance site of Guinnerso containing significant quantities of these seeds. Sedge (*Carex* spp.) seeds and small rhizomes / culm bases were also recovered in quantity from nearly all the blocks, either stemming from the occasional burning of peaty turf or the incorporation into the hearth of fodder gathered from the heath.

Wood and timber were the most obvious resources available from any woodland. Small-scale woodland management may have been in place in the Mid to Late Iron Age from the evidence of pine from the conflagration level in Dun Bharabhat and coppiced hazel wattle work in the waterlogged upper Secondary Roundhouse levels at Loch na Beirgh. There are also a number of other rare pieces of evidence suggestive of more small-scale and opportunistic gathering from any possible local woodland, such as hazel nutshells and single seeds of rowan and birch. Seaweed and driftwood would also have been gathered from the seashore.

9.8 Integration and synthesis

The nature of resource exploitation only changed slightly between the domestic blocks, though there seems to be two main periods of similar economic practice for which there is a large quantity of data. The first period relates to the Mid to Late Iron Age I blocks and the second period relates to the Late Iron Age II to Norse blocks. The main difference between the two sets of blocks was the diversification into the cultivation of oat and flax in the later period. In both periods, five main zones of exploitation were identified forming a theoretical economic landscape for most of the domestic blocks. The zones included;

1) arable zone (crops grown and harvested).
2) moorland (peat , heather, berries and sedges collected).
3) shoreline (seaweed and driftwood collected).
4) small areas of managed woodland/inaccessible cliffs for deciduous and pine timber procurement (limited management and control).
5) rough grassland for grazing and production of fodder.

This provisional model does not represent landscape reconstruction in the physical and spatial sense, but rather highlights an economic landscape that can be reconstructed to a greater or lesser extent for most sites that produce ecofactual and artefactual assemblages. A reconstruction of the physical economic landscape is only possible through the integration of the off-site palaeoenvironmental proxy records, such as pollen. Such integration allows the resources to be placed in their landscape context and the Mid Iron Age and Late Iron Age blocks from the Bhaltos peninsula represent a good case study of such an approach. There was also a seasonal dimension to these theoretical economic landscapes, highlighting the annual cycles of plant procurement and management. The cycles from both of the main periods required detailed planning and organisation of labour, as well as stability in land holding and the existence of social controls over the various resource zones, for example the peat banks and shorelines. It is proposed that the annual cycle in the later period involved increased complexity, with extensification of arable land for oat cultivation and investment of time and labour into flax cultivation and processing.

A wider review of the archaeobotanical remains from across Atlantic Scotland revealed similar issues of continuity and change for cultivation practices and wood procurement during the first millennia. Barley was the dominant crop for most of the blocks, with the six-row species identified from all but one of the blocks containing barley. This seems to be at odds with the evidence from West Lewis, where two-row barley was present in significant quantities in a number of the domestic blocks. Conversely, variability existed between the different areas in terms of the selection of the barley variety. In general, hulled barley was dominant throughout the first millennia in Shetland and the Atlantic West, with the occasional recovery of naked barley as a contaminant of the hulled crop. However, the situation was more complex in Orkney, Caithness and Sutherland. From the Early to Mid Iron Age, both varieties were grown at the same time, though in mutually exclusive crops with little mixing. It was only during the first millennium AD that the naked variety was gradually phased out in preference to hulled barley.

The uptake and cultivation of oat is also not uniform across the region. In Shetland, the initial significant quantities appeared in the Mid Iron Age with increased use throughout the first millennium AD but no obvious dramatic increase at the end of the millennium. In Caithness, significant quantities were recovered from Early Iron Age blocks, though the general pattern was again one of increased use throughout the first millennium AD. In Orkney, oat was present in a number of Mid Iron Age assemblages but only in very small quantities and so was interpreted as a weed contaminant of the barley crop. Again, increased use of oat in Orkney throughout the first millennium AD was noted but with a significant increase in proportions of the assemblages at the Late Iron Age II / Norse transition, a pattern similar to that observed from the Western Isles. Flax cultivation seems to become a significant component at certain sites in the latter half of the first millennium AD and the variable uptake supports the assertion of certain social controls over its growth and processing.

In general, detailed interpretation on agricultural practice was only possible from sites where rigorous bulk sampling was undertaken. Also, the taphonomy of the remains carbonised in domestic hearths meant interpretation was limited. However, despite these qualifications, it is possible to suggest that most of the sites seemed to have had barley cultivation immediately adjacent to the settlement. No single soil condition was favoured, but light free-draining soils were repeatedly indicated from probable arable weed seeds. More marginal acidic and damp areas were also indicated, but usually on the later sites with significant quantities of oat. This may represent the beginnings of the infield / outfield system, with the barley grown in the core area for thousands of years and the expansion of oat cultivation into the hinterland areas, generally in the mid to late first millennium AD. Soil amendment of this core area seems to be routinely undertaken, through the input of dung, midden material, seaweed, seaweed ash and sometimes turf. Culm bases and low-lying weed seeds were common across nearly all of the assemblages that may indicate up-rooting as a harvesting strategy. This would be easy in light, sandy soils and would maximise the straw yield. However, caution in interpretation must be exercised as some of the wild components, especially the culm bases, could have been introduced from turf fuel. Most of the early crop-processing stages were undertaken away from the vicinity of domestic hearths, probably near to the fields themselves. Therefore, most of the cereal remains stem from accidents in final processing stages adjacent to the domestic hearth or cooking accidents, though certain rare contexts, such as conflagration deposits, provide evidence for the earlier stages as well. These deposits are particularly important for analysing agricultural practice, due to the relative lack of mixing with other plant material from different activities. A few sites suggested storage of barley in the ear form, but this was hard to verify as a consistent strategy due to the generally poor preservation of most of the assemblages.

One of the more interesting points to have come from the survey of the evidence in Atlantic Scotland was the changing nature and diversification of the arable base that occurred in the Late Iron Age and Norse periods. Similar patterns of Iron Age intensification have been proposed from the North-East of England and in the fertile areas of the North-East and Tyne/Forth zones in Scotland. Analysis of 25 chronological blocks from across the Western Isles suggested that intensification and extensification of the arable economy was underway throughout the first millennium AD. A complementary picture was shown by the increased grain concentration and cereal diversification from the on-site archaeobotanical assemblages and regional pollen signal. A number of models were proposed to explain this pattern, including;

1. Methodological explanations.
2. Increased sophistication in processing and storage.
3. Increase in population.
4. Production of surplus for trade, in the form of beer for example.
5. Change of emphasis in the agricultural economy.
6. The provision of buffering mechanisms.

The review of the evidence of charcoal remains from across Atlantic Scotland in the first millennia highlighted a few regional variations. In general, heather and coniferous timber were the most common types in the Northern and Western Isles, with lesser proportions of deciduous material. The heather would have derived from deliberate gathering for various uses, such as kindling, furnishings, bedding and basking-making. It could also have been introduced through the use of peaty turf and peat as fuel. The conifers were largely driftwood derived, though pine may have been locally managed on a small-scale. Some of the deciduous material could also have grown, or even been managed, in certain sheltered and inaccessible areas. However, it is also possible that some of this material was driftwood derived and a small proportion perhaps even traded with the mainland, as part of objects or as timber in its own right. The assemblages from the mainland show a slightly different pattern with less heather and coniferous timber and more deciduous roundwood and timber. This perhaps reflects a greater reliance on the regionally available mixed-forest than the opportunistic gathering and small-scale management proposed for the Northern and Western Isles.

The biggest problem with the data set reviewed was the lack of certainty over the specific use and derivation of the remains. This again stems from the taphonomic model of carbonisation in the domestic hearth that mixes plant material from an unknown number of human activities and behaviour. However, the conflagration layer from Dun Bharabhat demonstrated the increased level of archaeological and archaeobotanical interpretation possible from the remains of conflagrations. Questions of timber procurement strategies can also be addressed through analysis of waterlogged *in situ* structural remains, such as the spruce post and hazel wattlework from Loch na Beirgh. From the direct evidence from these remains from various Mid to Late Iron Age contexts, timber procurement in the Northern and Western Isles was based upon the gathering of driftwood, such as spruce, and the use of smaller timbers of species that could have been obtained locally, such as willow and hazel. This pattern of procurement does not require large-scale trade networks of timber and the consequent trade deficits that would result on an island – mainland axis.

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NB: Published papers with data from author's PhD analysis (*) are attached as Appendix C.

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Figures

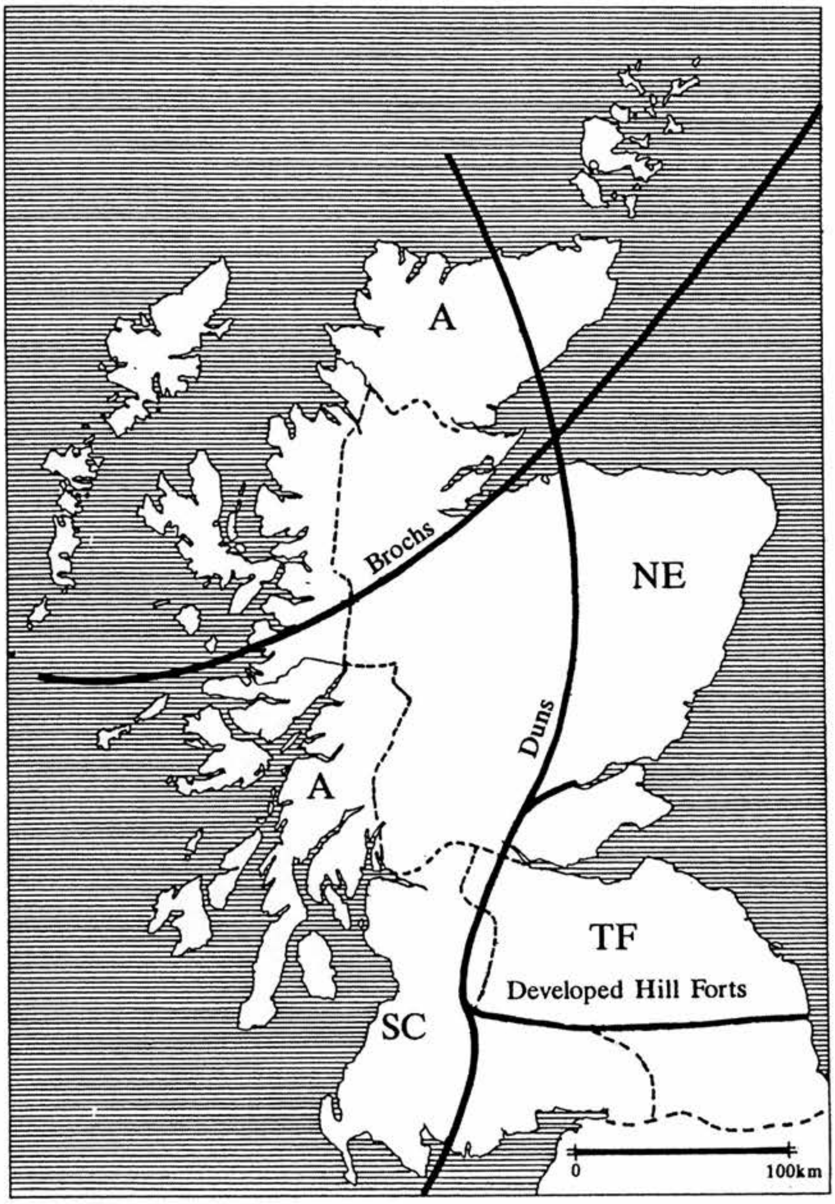


Figure 1.1: Piggott's Provinces in Iron Age Scotland (amended by Armit & Ralston, 1997 to incorporate isohyets defining the principal areas of some major site types as defined by Cunliffe)

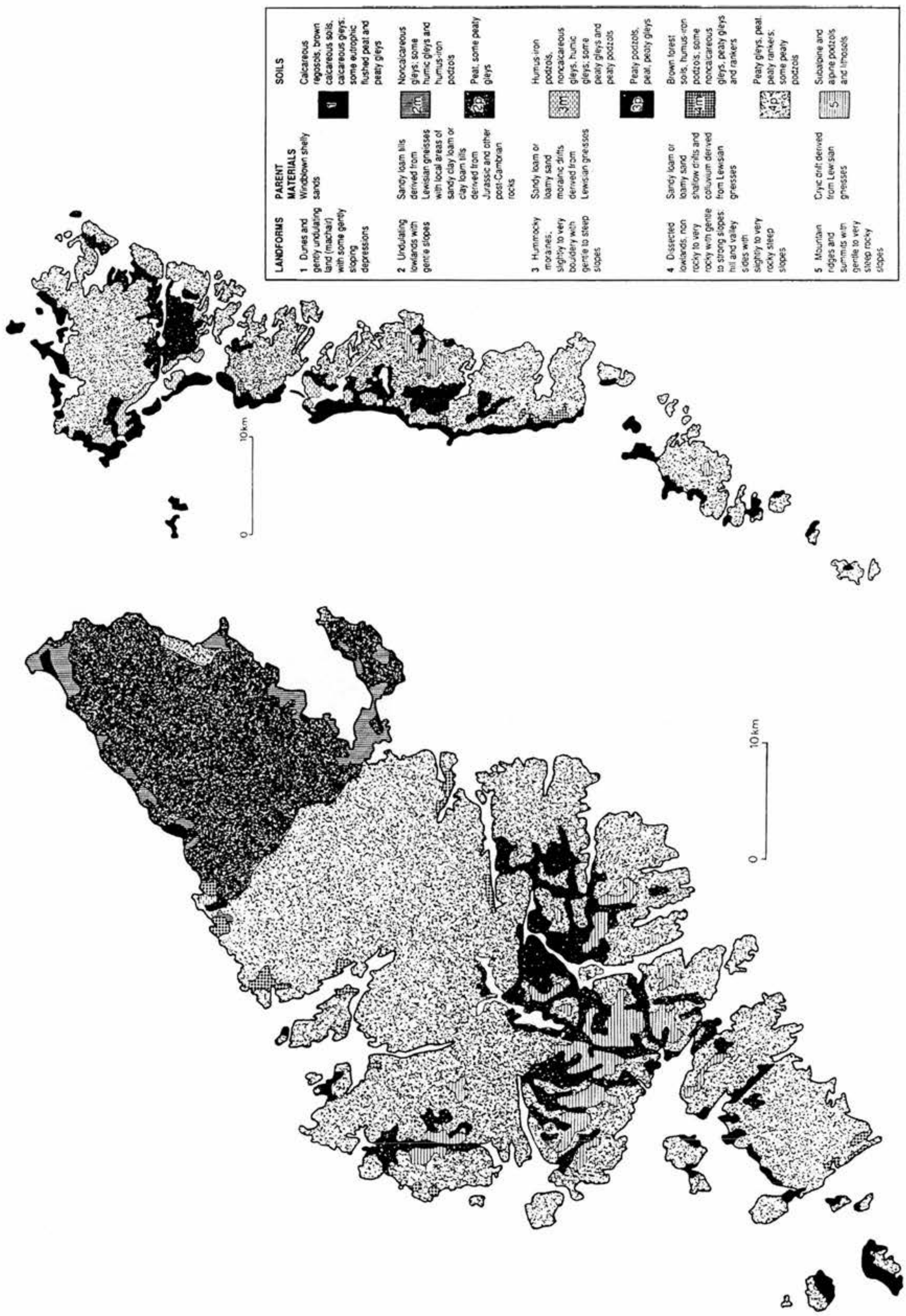


Figure 2.1: Modern soil and landscape block distribution of the Western Isles (Source: Hudson, 1994)

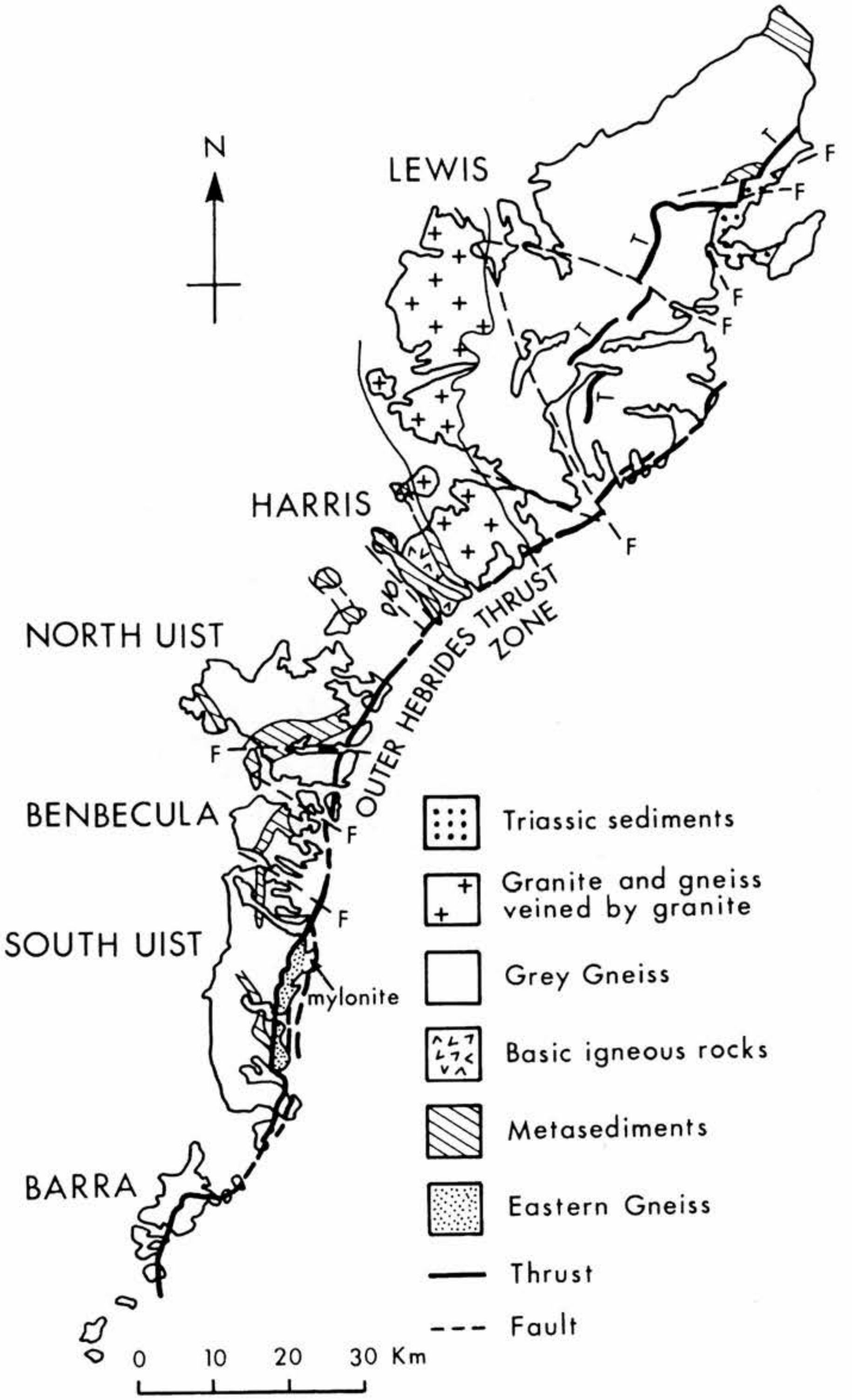


Figure 2.2: The solid geology of the Western Isles (Source: Gribble, 1994)

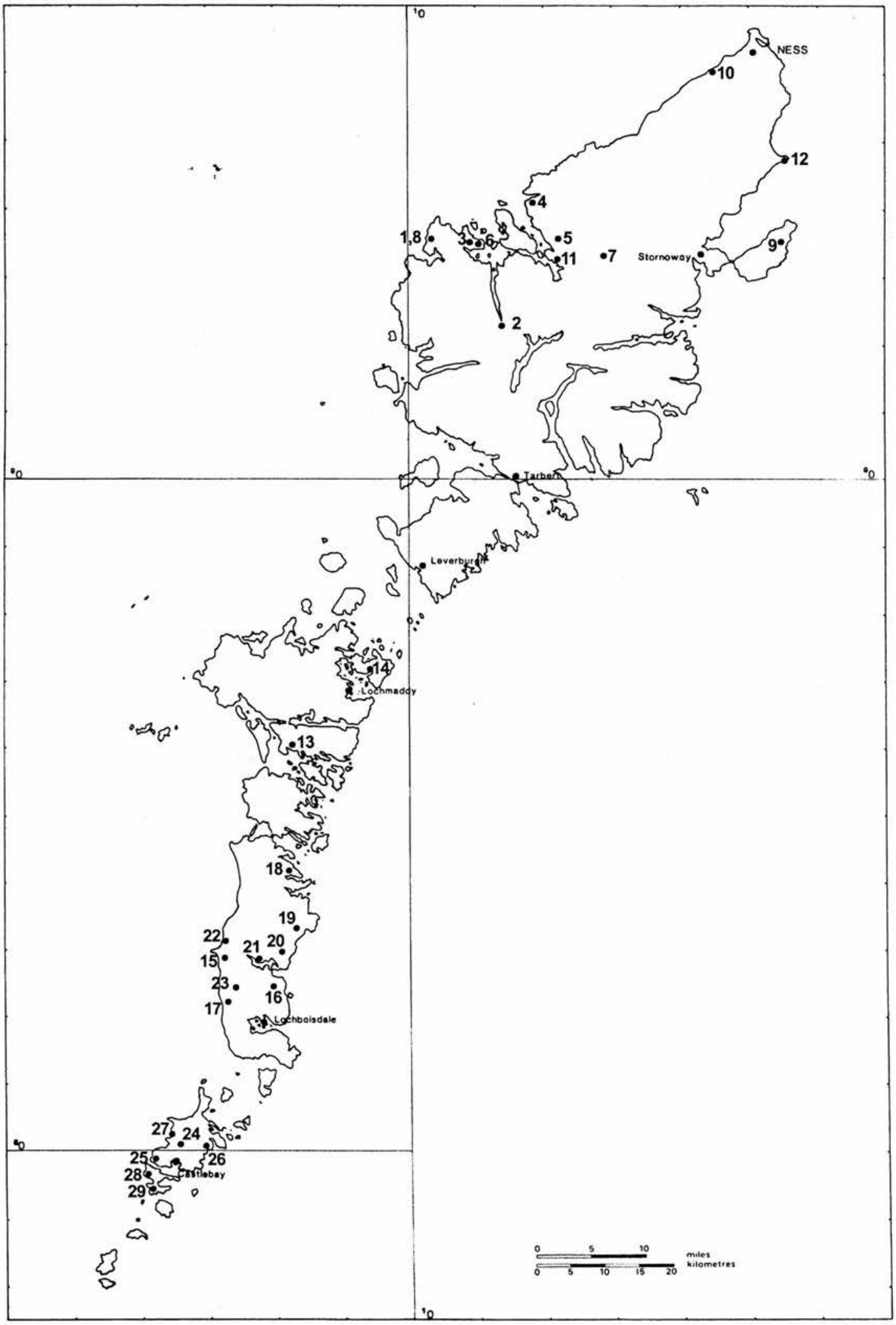


Figure 2.3a: Location of key palaeoenvironmental sites in the Western Isles (Key overleaf)

Key to Figure 2.3a

Label	Site name	Type of evidence	Reference
	Lewis and Harris		
1	Guinnerso East Moor	Holocene humification	Coles, in prep.
2	Little Loch Roag	Late glacial / Holocene pollen	Birks & Madsen, 1979
3	Loch Bharabhat	Late glacial / Holocene pollen	Lomax, 1997
4	Loch Builaval Beag	Late glacial / Holocene pollen	Fossitt, 1996
5	Loch na Beinne Bige	Late glacial / Holocene pollen	Edwards *et al.*, 1994
6	Loch na Beirgh	Mid - Late Holocene pollen	Lomax, 1997
7	Loch nan Cnamh	Holocene humification	Coles, in prep.
8	Loch Ruadh Guinnerso	Late glacial / Holocene pollen	Flitcroft, 1997
9	Sheshader	Mid - Late Holocene pollen	Newell, 1988
10	Toa Galson	Late Quaternary pollen	Sutherland & Walker, 1984
11	Tob nan Leobag	Holocene pollen	Bohncke, 1988
12	Tolsta Head	Late Quaternary pollen	von Weymarn & Edwards, 1973
	North Uist		
13	Bharpa Carinish	Mid - Late Holocene pollen	Crone, 1993
14	Loch Portain	Mid - Late Holocene pollen	Mills *et al.*, 1994
	South Uist		
15	Kildonan Glen	Late glacial / Holocene pollen	Brayshay & Edwards, 1996
16	Loch Airigh na h-Aon Oidhche	Late glacial / Holocene pollen	Edwards & Whittington, 1994
17	Loch an t-Sil	Late glacial / Holocene pollen	Edwards & Whittington, 1994
18	Loch a'Phuinnd	Late glacial / Holocene pollen	Fossitt, 1996
19	Loch Hellisdale	Late glacial / Holocene pollen	Brayshay & Edwards, 1996
20	Loch Lang	Late glacial / Holocene pollen	Bennett *et al.*, 1990
21	North Locheynort	Late glacial / Holocene pollen	Edwards & Whittington, 1994
22	Peninerine	Early - mid Holocene pollen	Edwards & Whittington, 1994
23	Reineval	Late glacial / Holocene pollen	Edwards & Whittington, 1994
	Barra		
24	Borve mire	Late glacial / Holocene pollen	Ashmore *et al.*, 2000
25	Glen Bretadale	Late glacial / Holocene pollen	Gilbertson *et al.*, 1995b
26	Lochan na Cartach	Late glacial / Holocene pollen	Brayshay & Edwards, 1996
27	Port Caol	Late glacial / early Holocene pollen	Brayshay & Edwards, 1996
	Vatersay		
28	Kerb Cairn VS7	Bronze Age OGS pollen	Edwards & Craigie, 2000a
29	Kerb Cairn VS4B	Bronze Age OGS pollen	Edwards & Craigie, 2000b

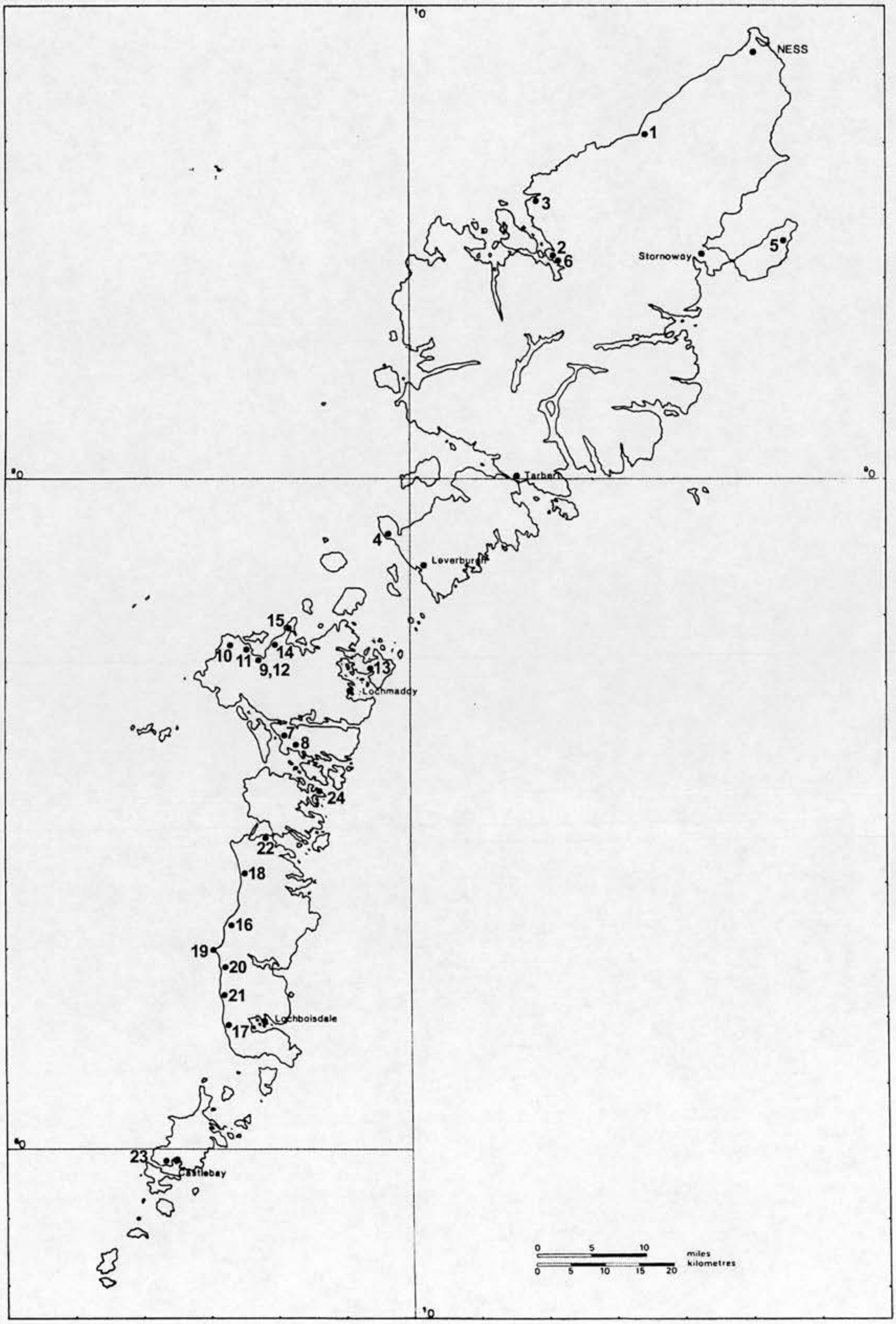


Figure 2.3b: Location of archaeological sites discussed in Chapter 2 (Key overleaf)

Key to Figure 2.3b

Label	Site name	Description	Types of evidence	Site reference
	Lewis and Harris			
1	Barvas	Norse settlement	Plant macros (Dickson, unpubl.)	Cowie, 1986, 1987
2	Calanais farm	LBA/EIA fieldsystem	Pollen (Verrill, 2000)	Flitcroft *et al.*, 2001
3	Dun Carloway	Broch tower	Structural	Armit, 1996
4	Northton	Late Neo/EBA settlement	Molluscs (Evans, 1971)	Simpson, 1976
5	Sheshader	LBA/EIA fieldsystem	Pollen	Newell, 1988
6	Tob nan Leobag	LBA/EIA fieldsystem	Pollen (Bohncke, 1988)	Cowie, 1979
	North Uist			
7	Baleshare	Wheelhouse settlement	Plant macros (Jones, unpubl.)	Barber, forth.
8	Bharpa Carinish	Neo settlement	Plant macros (Boardman, 1993)	Crone, 1993
		LBA/EIA fieldsystem	Pollen	Crone, 1994
9	Ceann nan Clachan	LBA burnt mound and structure	Plant macros (Church, unpubl. b)	Armit & Braby, 1997
10	Eilean Domhnuil	Neo islet settlement	Various	Armit, 1996
11	Foshigarry	Wheelhouse settlement	Bone working	Hallen, 1994
12	Geiriscleit	Chambered cairn	Plant macros (Church, unpubl. a)	Armit, 1997
13	Loch Portain	LBA/EIA fieldsystem	Pollen	Mills *et al.*, 1994
14	Sollas	Wheelhouse settlement	Structural	Campbell, 1991, 2000
15	Udal	Multi-period settlement	Structural	Crawford & Switsur, 1977
	South Uist			
16	Bornais	LIA/Norse settlement	Structural	Sharples, 2000, 2001
17	Cladh Hallan	LBA/EIA settlement	Structural	Marshall *et al.*, 1999, 2000
18	Drimore	Norse settlement	Structural	Maclaren, 1974
19	Dun Vulan	Broch and later settlement	Various	Parker-Pearson & Sharples (1999)
20	Kildonan	Wheelhouse settlement	Plant macros (Grinter & Valamoti, unpubl.)	Zvelebil, 1990
21	Kilphedir	Norse settlement	Structural	Smith *et al.*, 2001
22	Hornish Point	Wheelhouse settlement	Plant macros (Jones, unpubl.)	Barber, forth.
	Barra			
23	Allt Chrisal	Late Neo/EBA settlement	Plant macros (Boardman, 1995)	Branigan & Foster, 1995
		Wheelhouse settlement	Plant macros (Smith, 2000)	Branigan & Foster, 2000
	Benbecula			
24	Rosinish	EBA field system	Plant macros	Shephard & Tuckwell, 1977

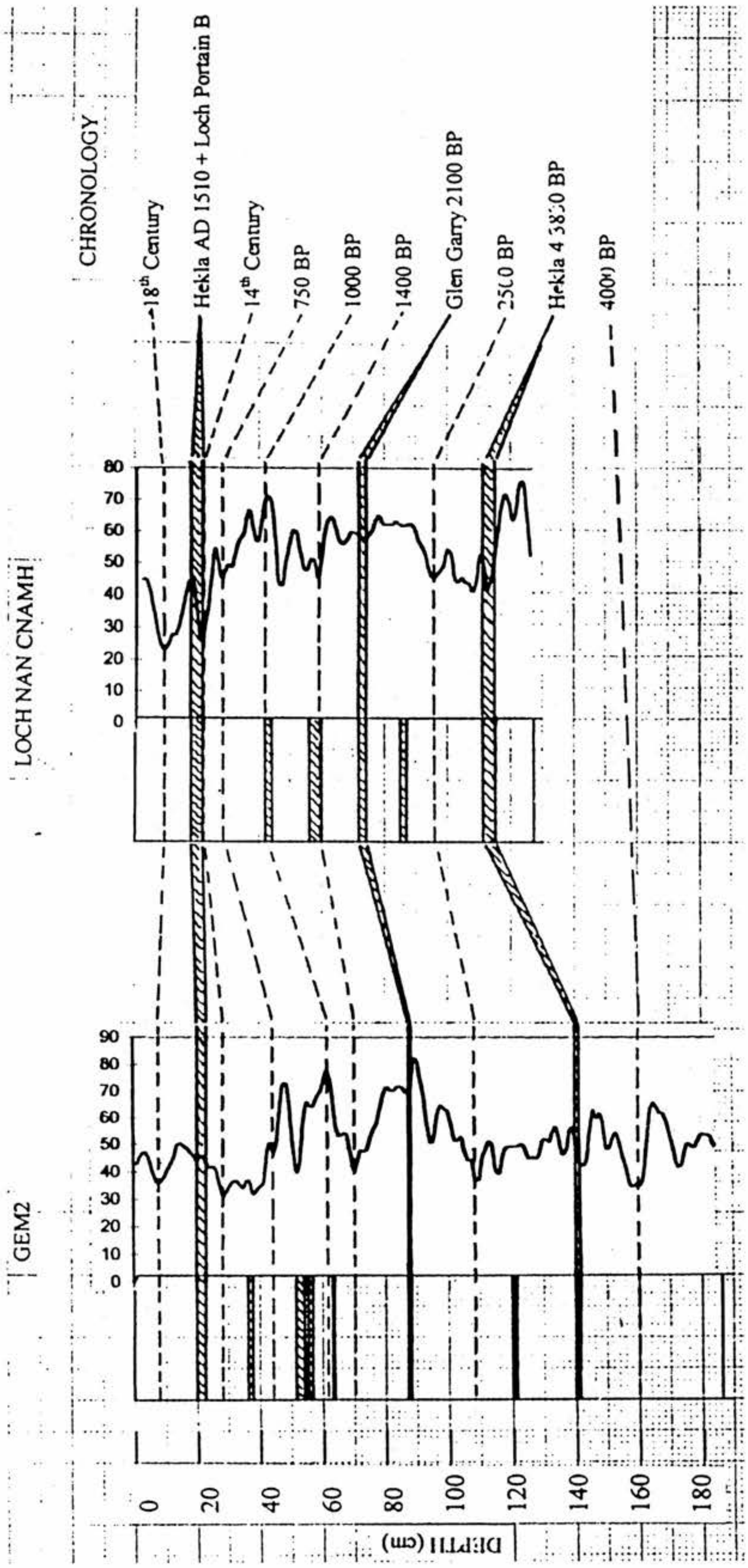


Figure 2.4: Humification profiles from Guinnerso East Moor and Loch nan Cnamh (Source: Coles, in prep.)

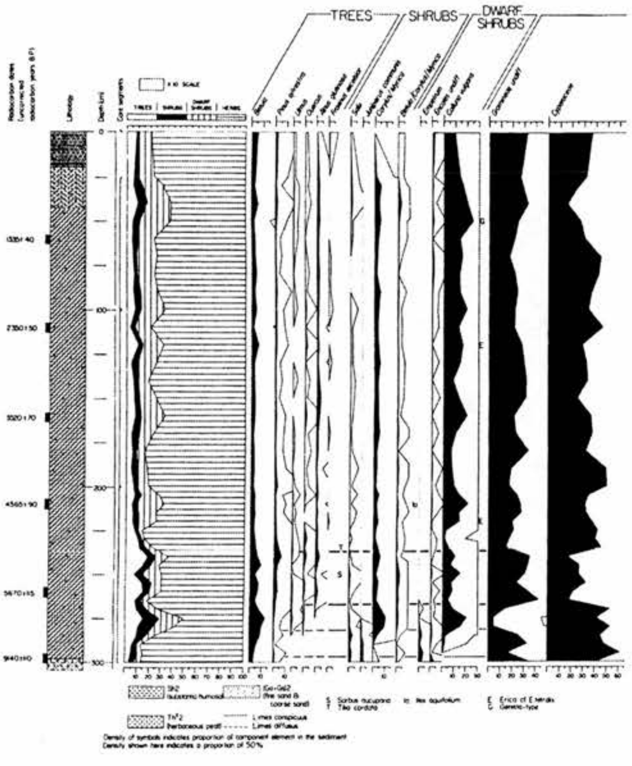


Figure 2.5a: Little Loch Roag summary diagram (Source: Birks & Madsen, 1979)

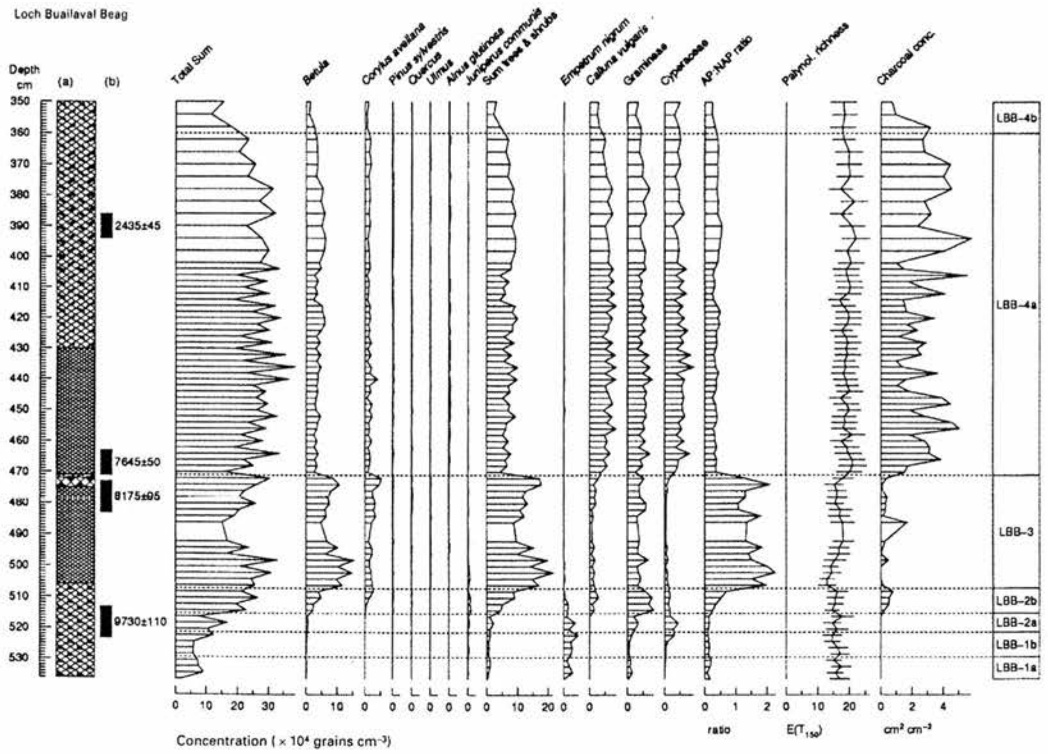


Figure 2.5b: Loch Buailaval Beag summary diagram (Source: Fossitt, 1996)

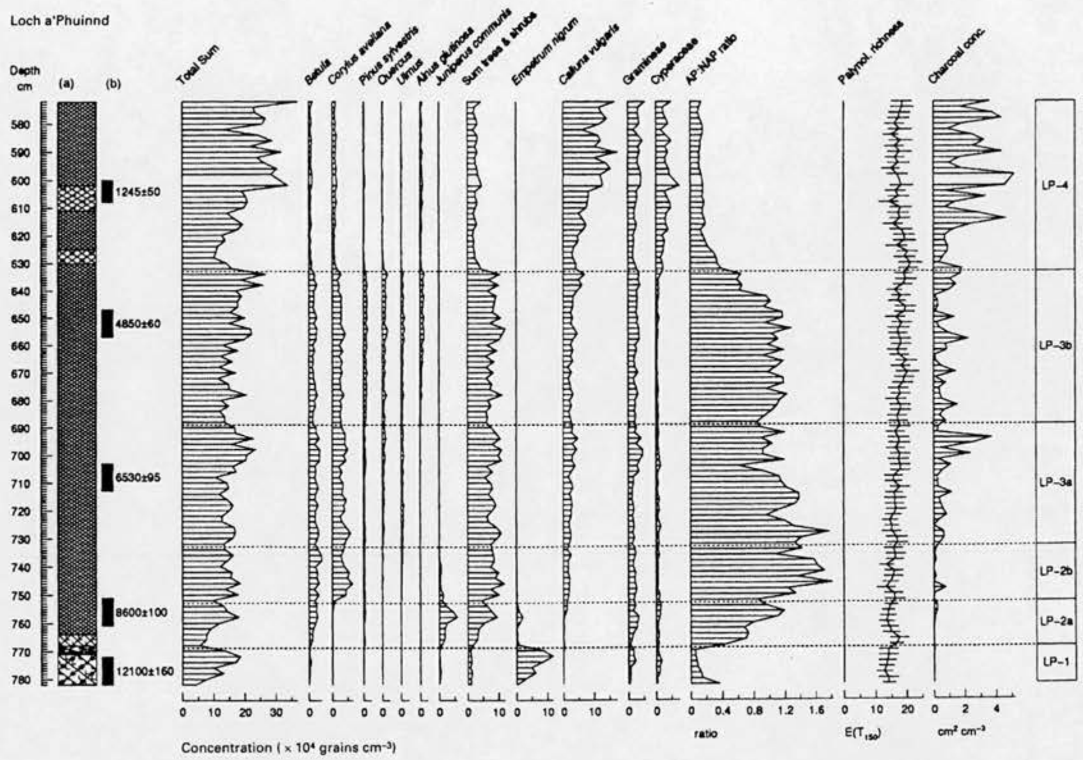


Figure 2.6a: Lcch a'Phuinnd summary diagram (Source: Fossitt, 1996)

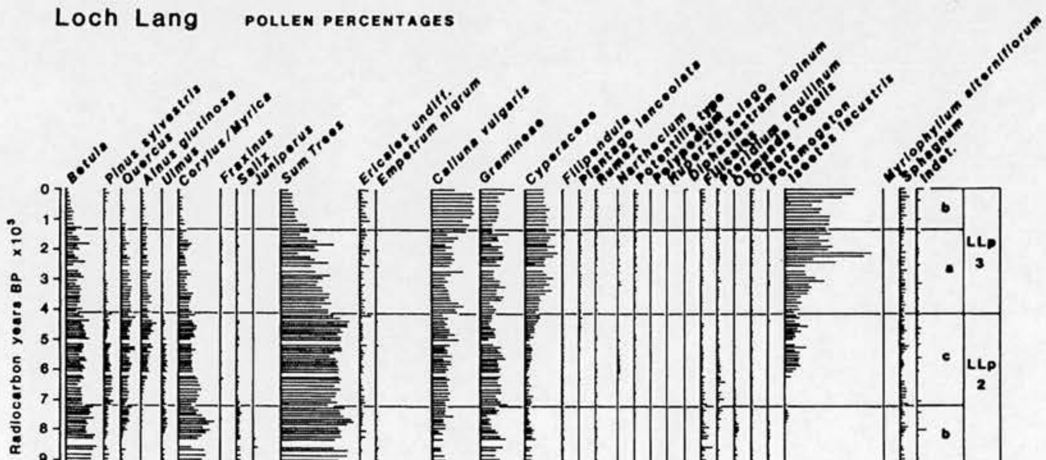


Figure 2.6b: Loch Lang summary diagram (Source: Bennett *et al.*, 1990)

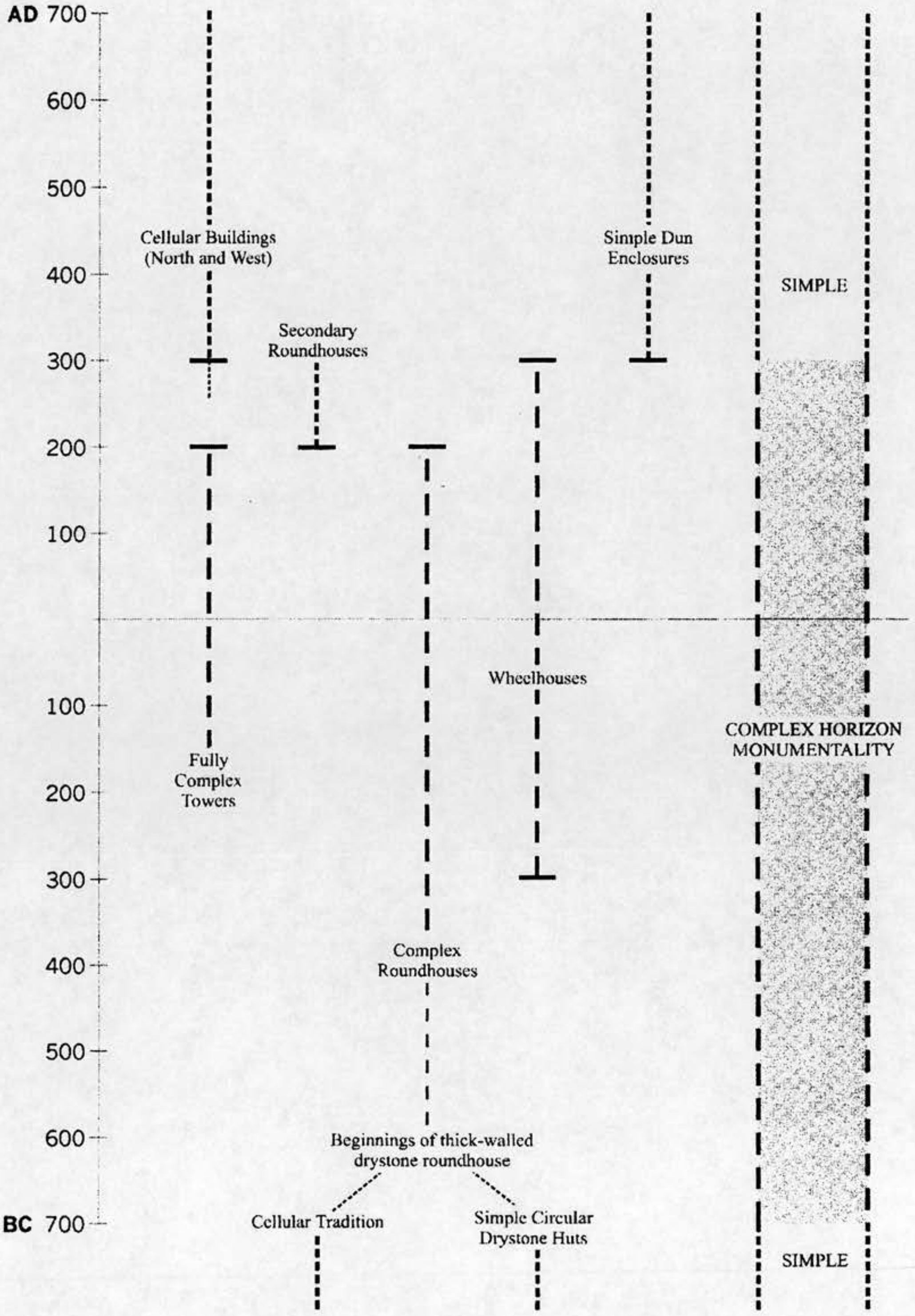


Figure 2.7: Later prehistoric drystone settlement development in Atlantic Scotland (Source: Henderson, 2000b)

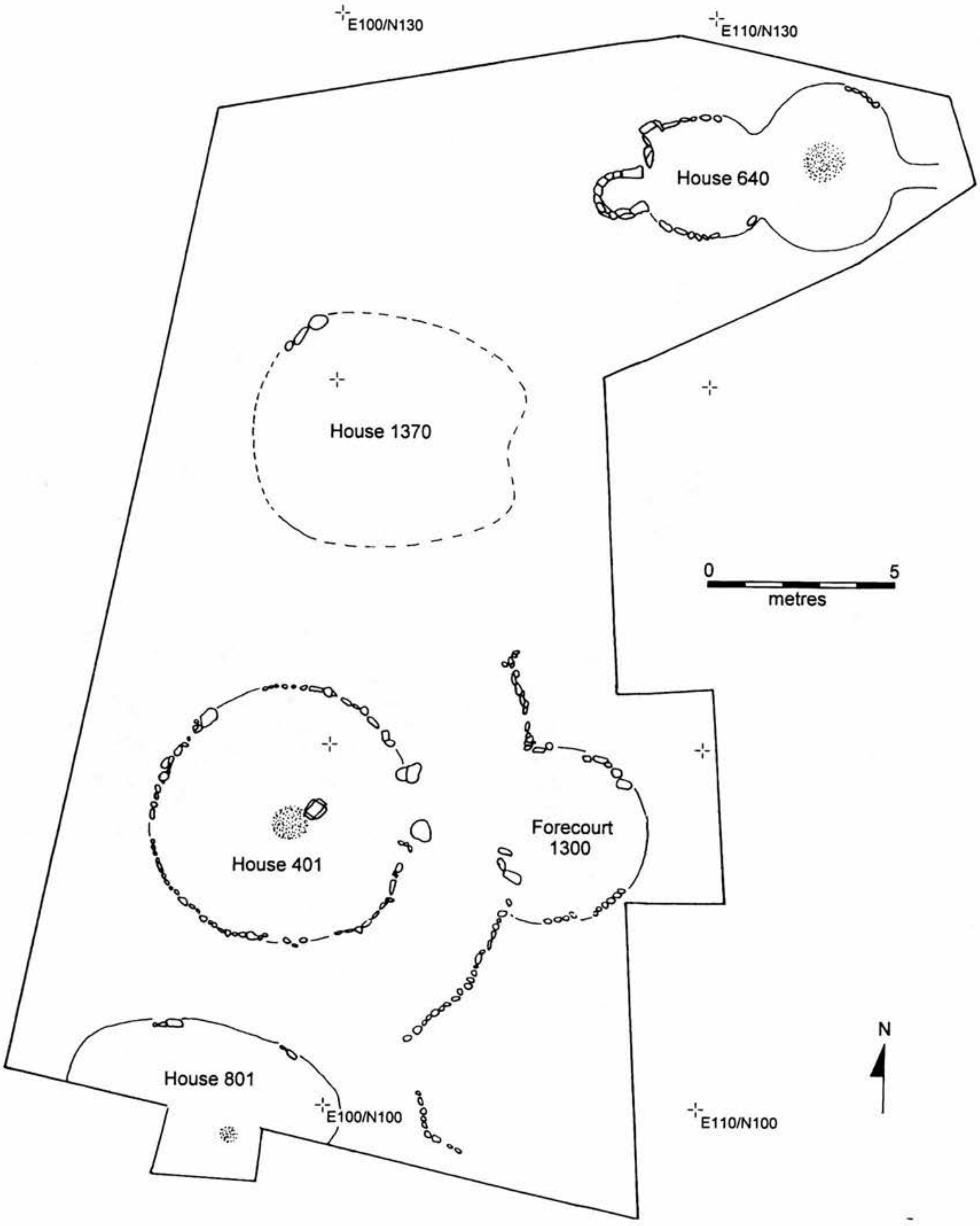


Figure 2.8: Late Bronze Age / Early Iron Age roundhouses at Cladh Hallan, South Uist (Source: Parker-Pearson *et al.*, 2001)

Figure 2.9: Dun Carloway, artist's reconstruction (Source: Armit, 1996)

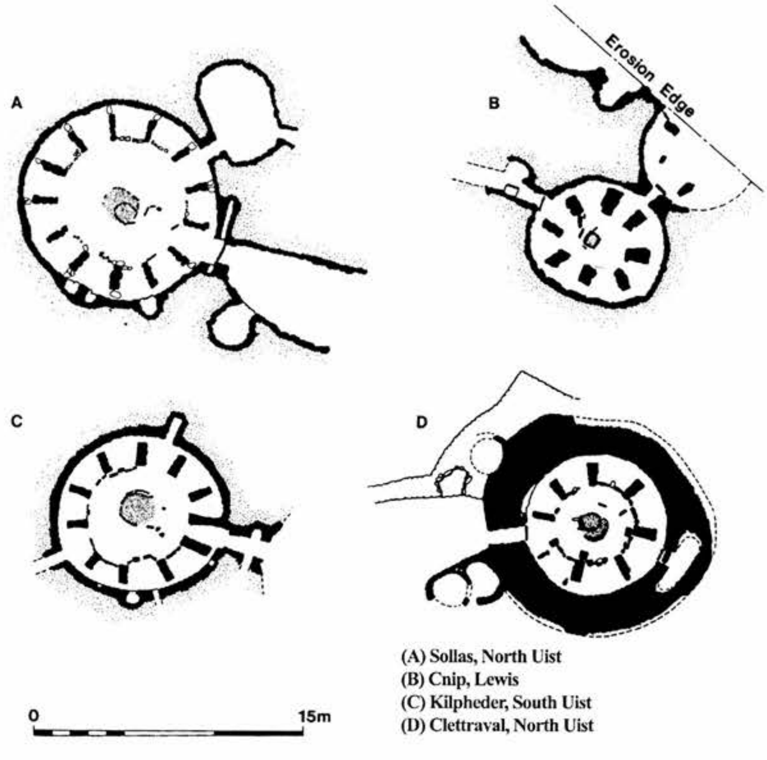


Figure 2.10: Wheelhouse plans from the Western Isles (Source: Armit, 1996)

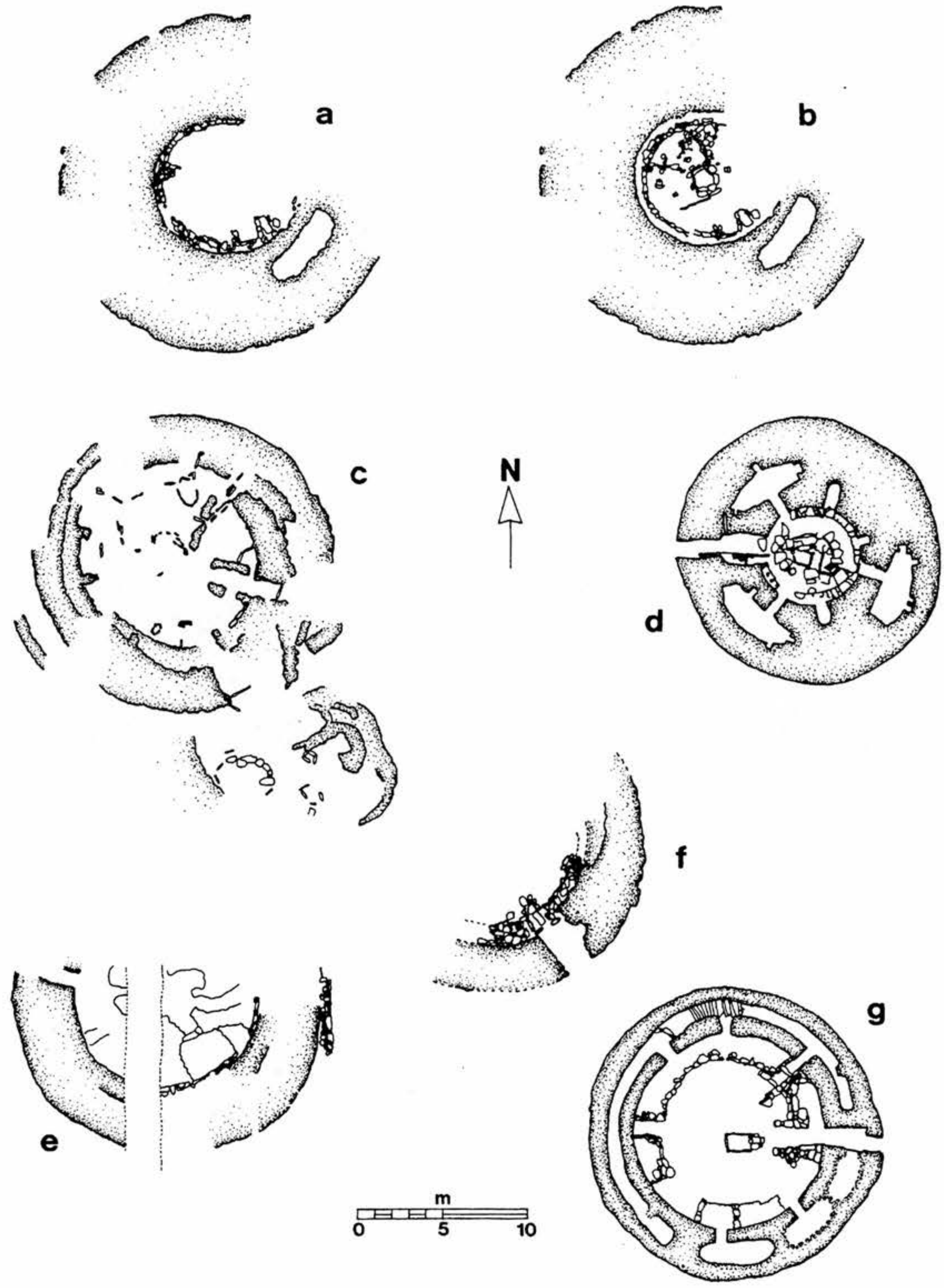


Figure 2.11: Secondary roundhouses in the interiors of Atlantic roundhouses: a) & b) Scalloway c) Skaill d) Mousa e) Old Scatness f) St. Boniface g) Loch na Beirgh (Source: Gilmour, 2000)

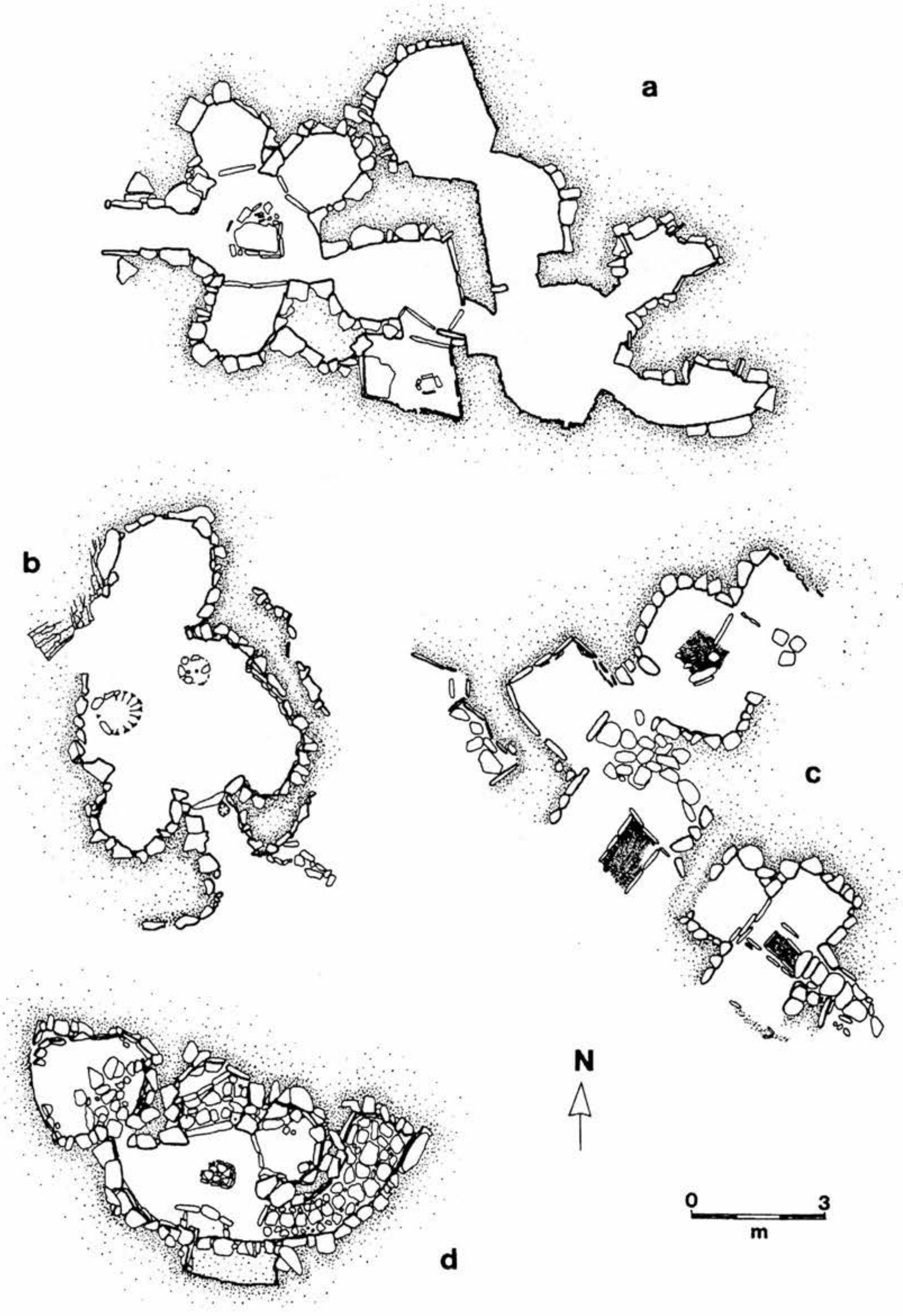


Figure 2.12: 'Shamrock' cellular features in Atlantic Scotland: a) Gurness b) Eilean Olabhat c) Buckquoy d) Loch na Beirgh (Source: Gilmour, 2000)

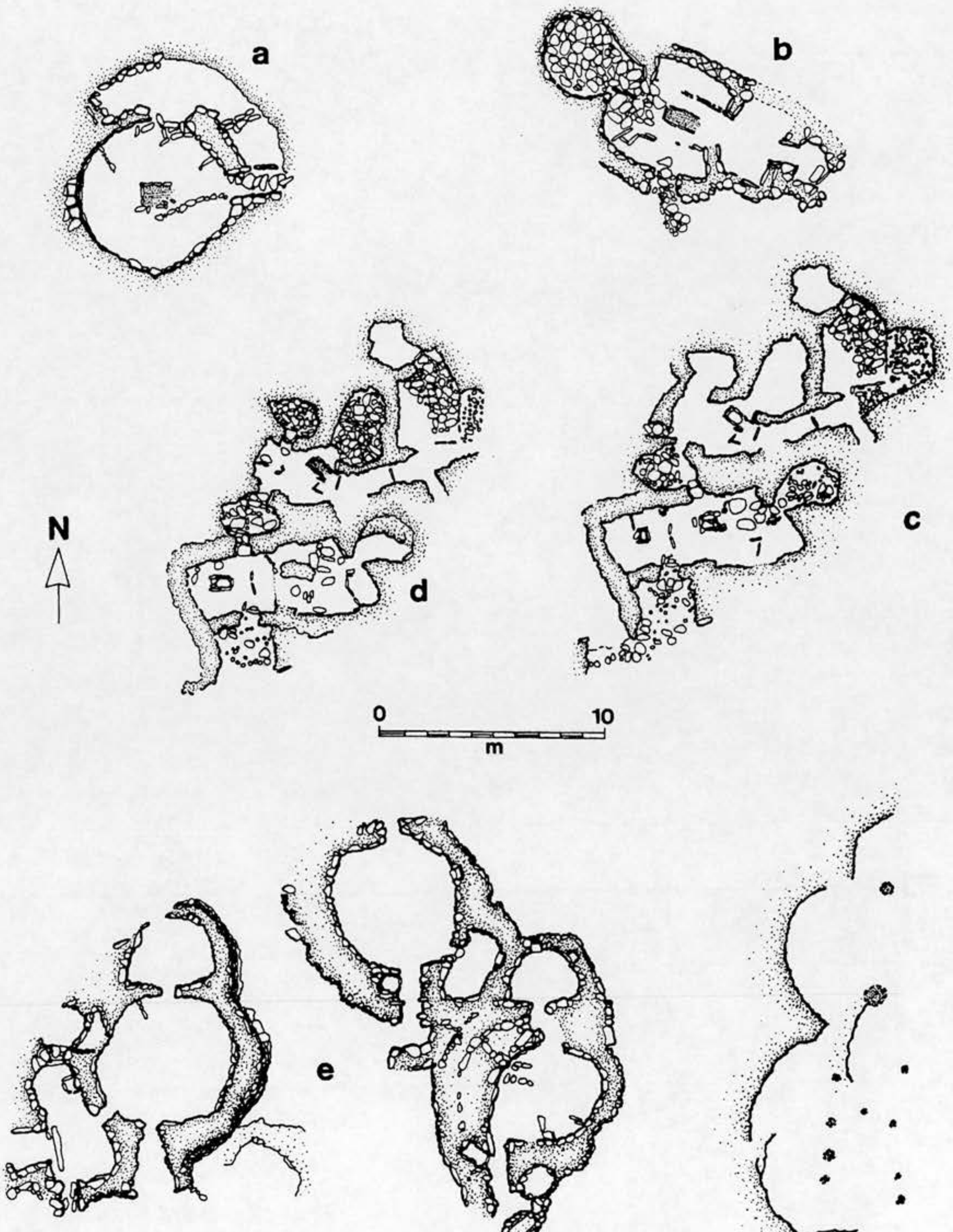


Figure 2.13: 'Figure-of-eight' buildings in Atlantic Scotland: a) Loch na Beirgh b) Buckquoy c & d) Howe, Phase 8 e) Bostadh f) Brough of Birsay (Source: Gilmour, 2000)

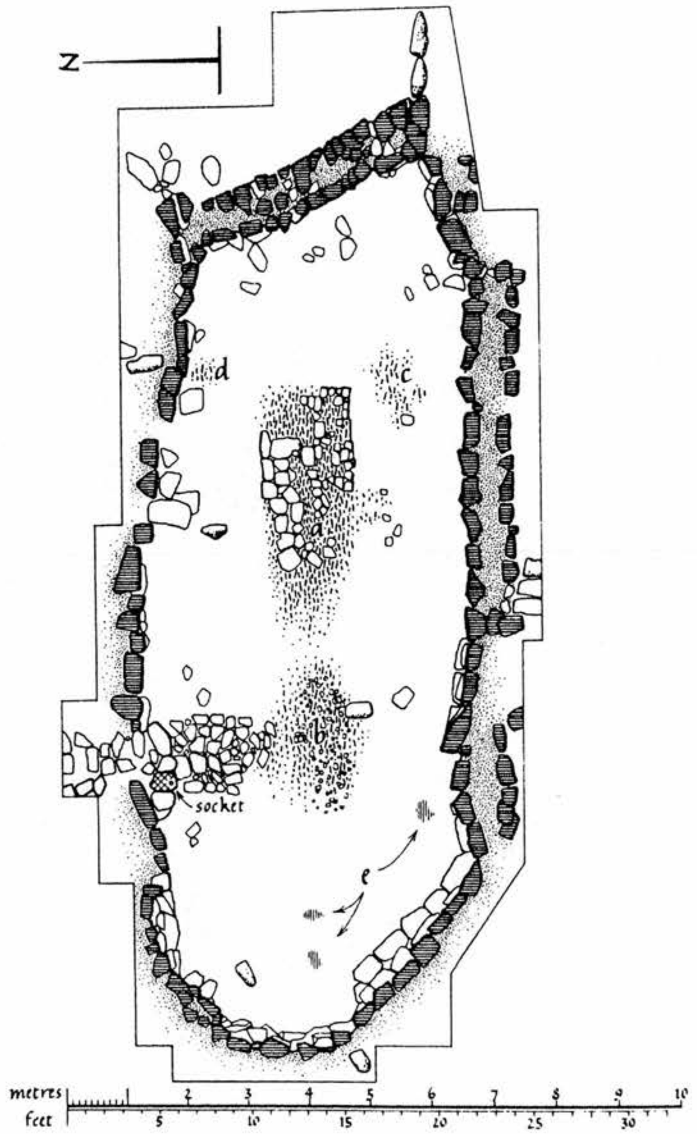


Figure 2.14: Norse building at Drimore, South Uist (Source: Maclaren, 1974)

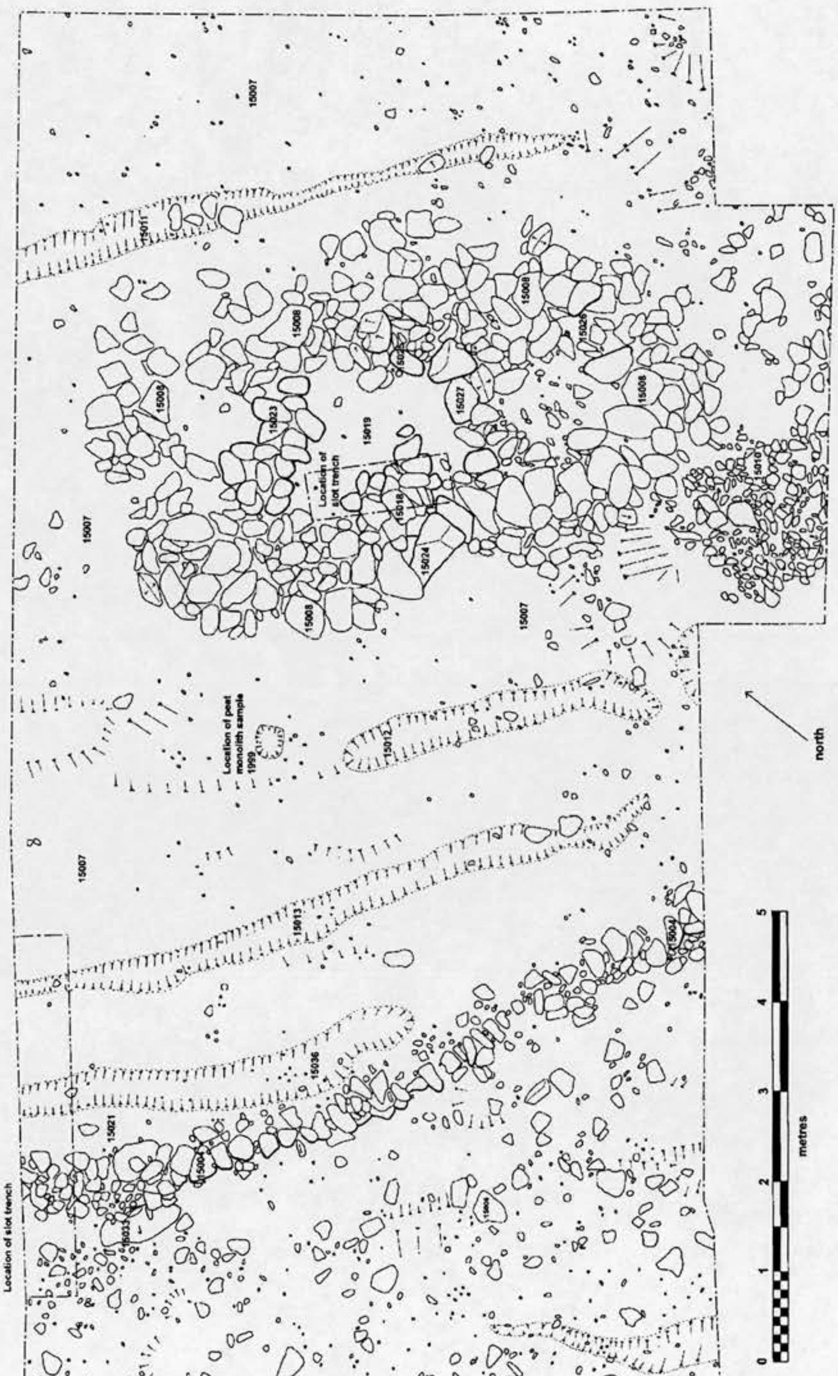


Figure 2.15: Calanais Farm field system (Source: Flitcroft *et al.*, 2001)

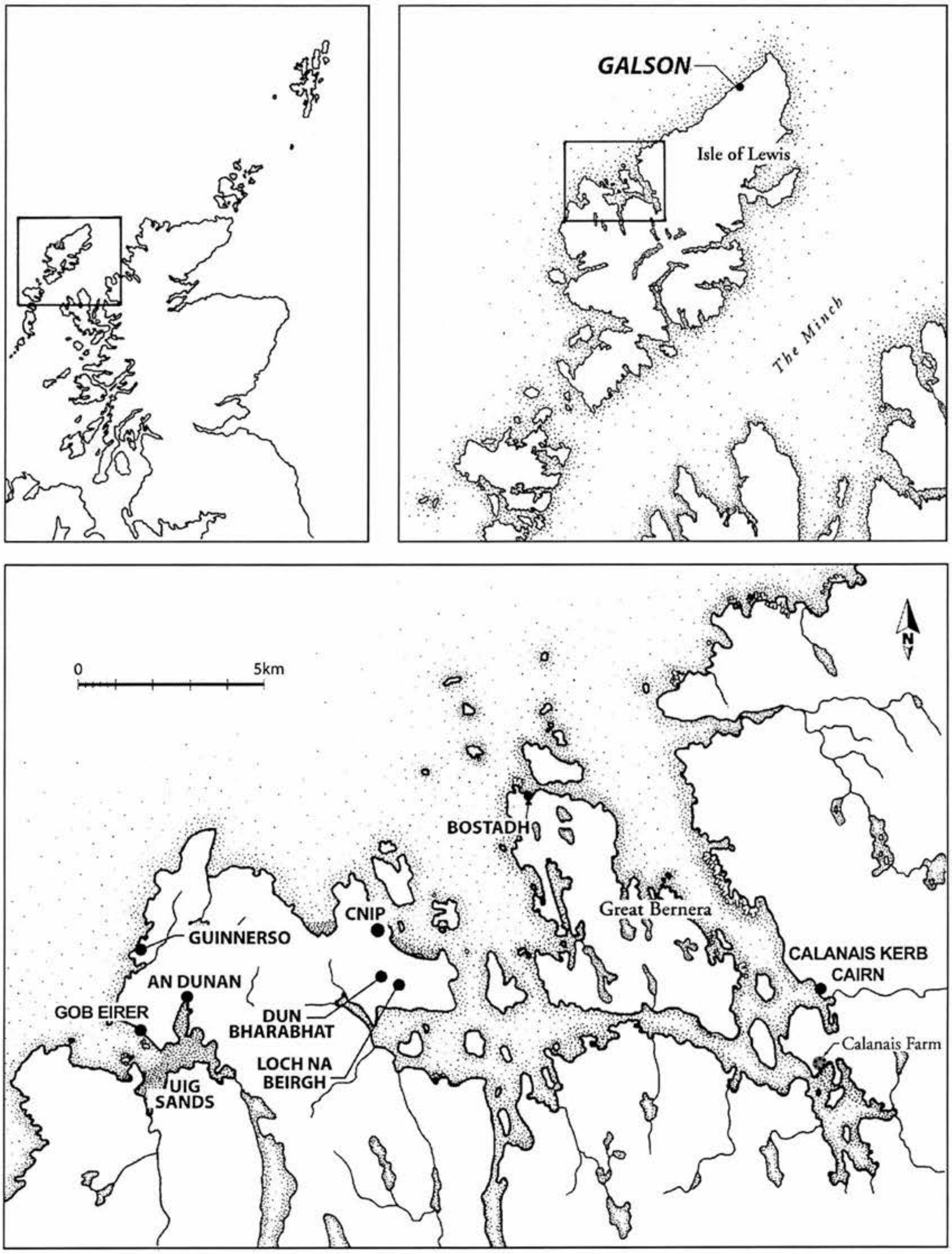
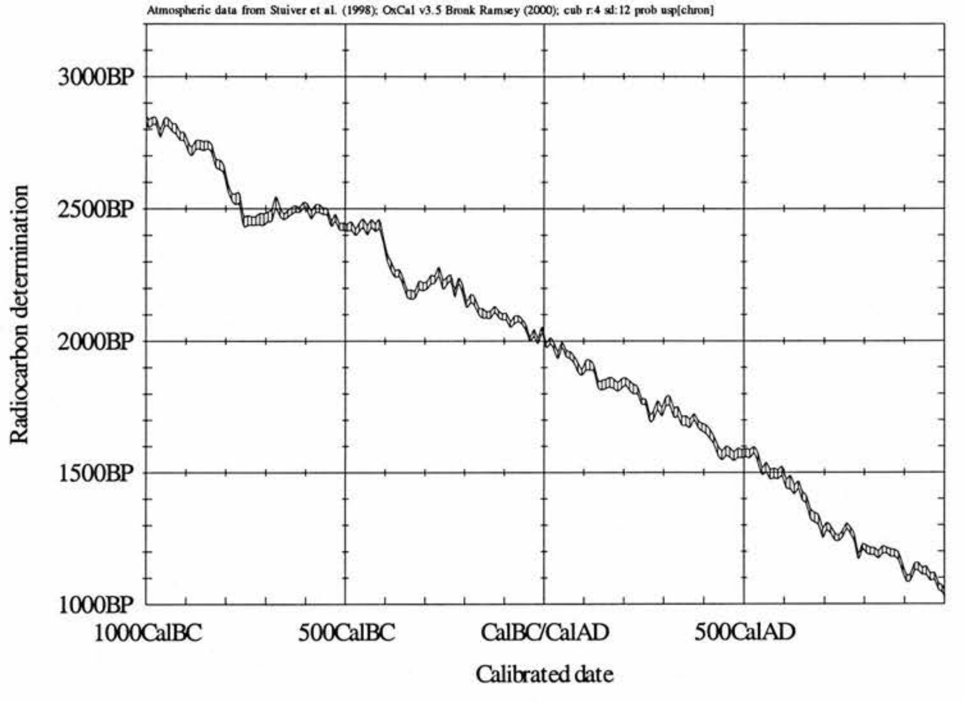


Figure 3.1: Map of study area and archaeological sites sampled



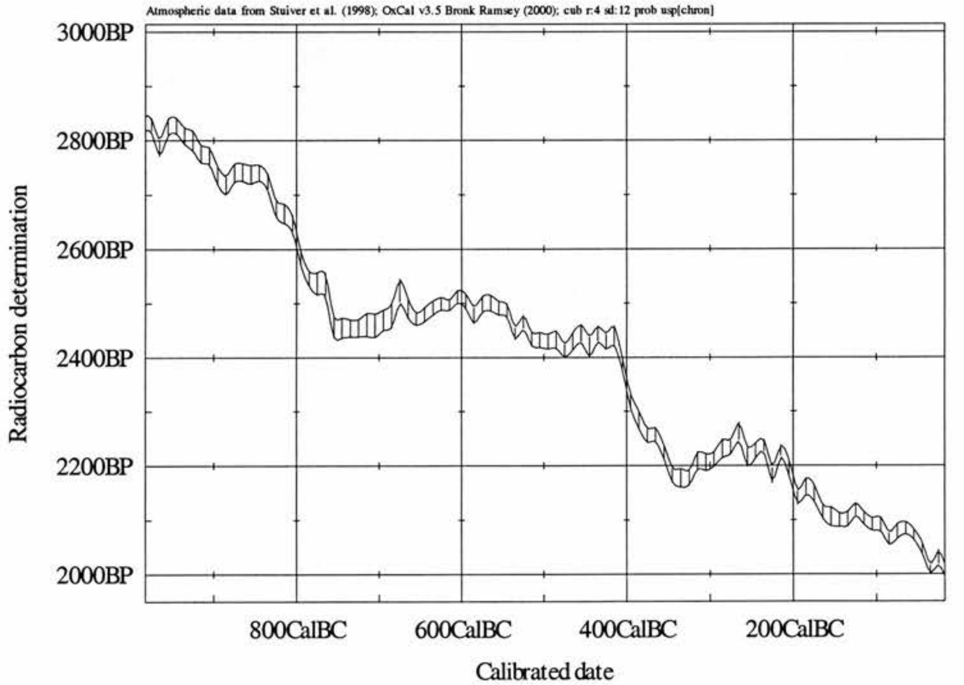


Figure 4.1: Radiocarbon calibration curve for first millennia BC and AD (Source: Bronk-Ramsey, 2000)

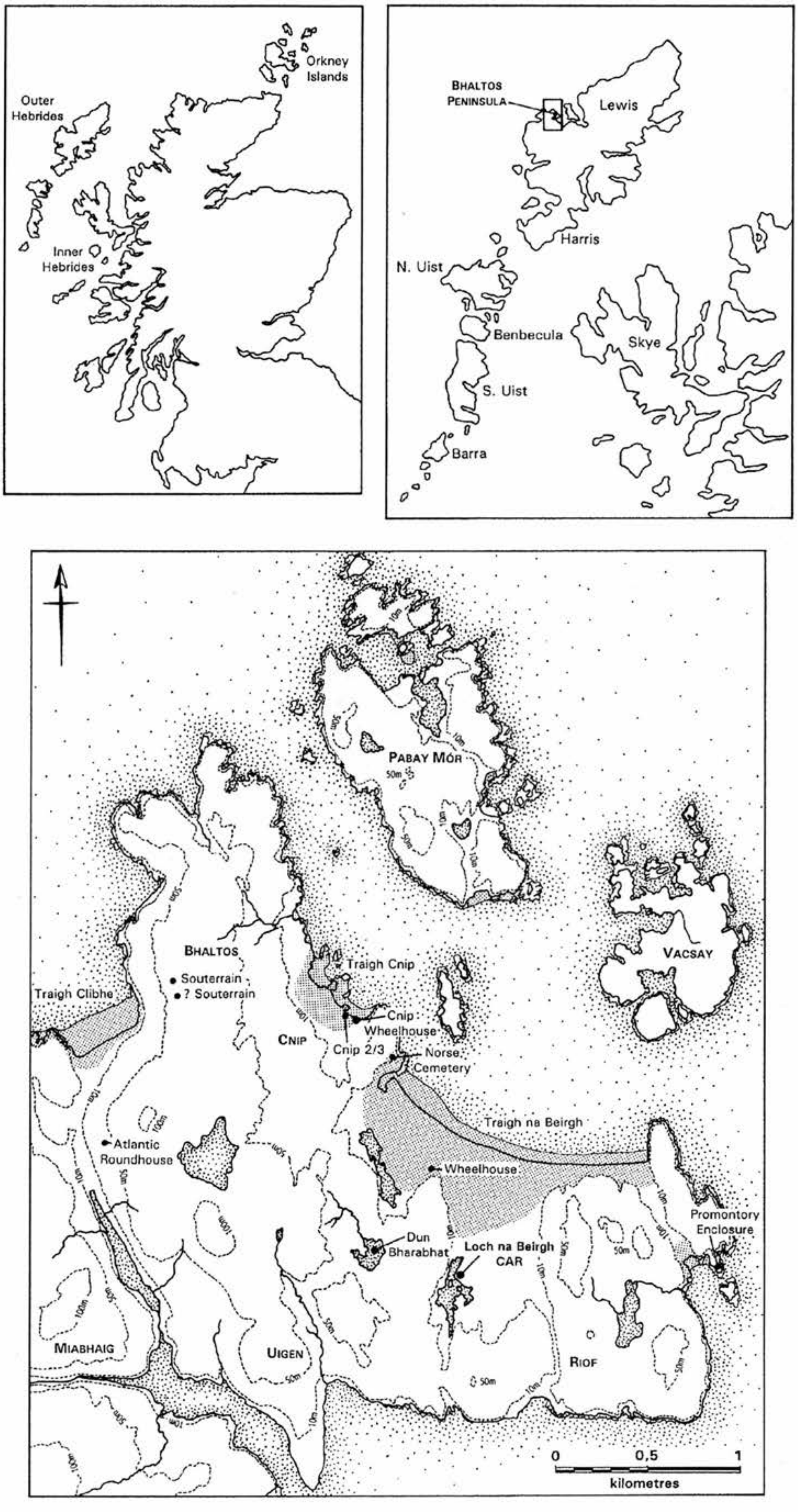


Figure 4.2: The Bhaltos Peninsula (Source: Ceron-Carrasco *et al.*, forth.)

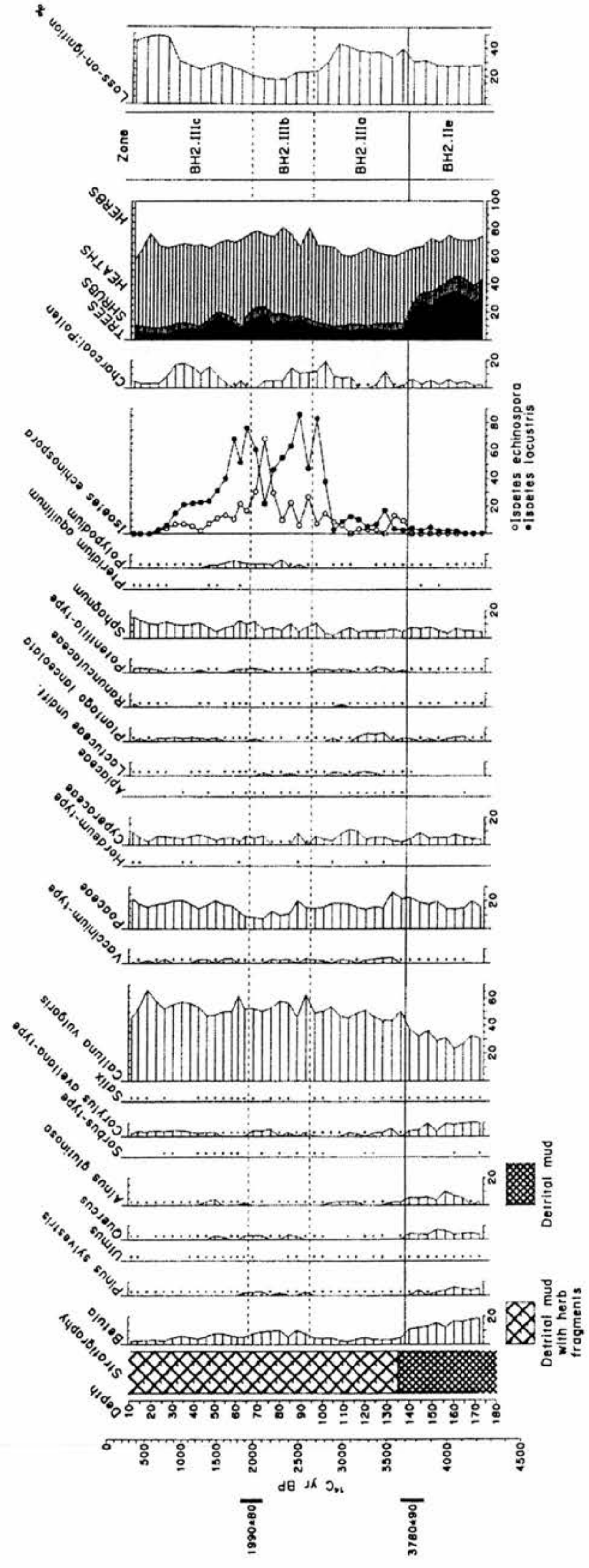
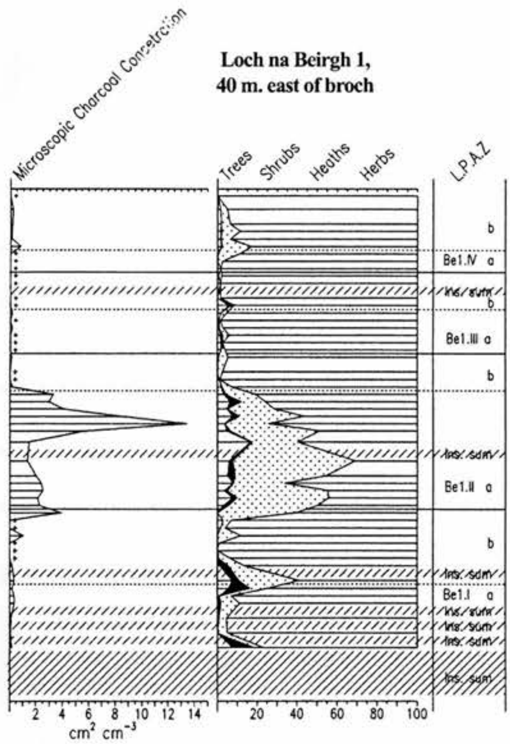


Figure 4.3: Pollen diagram from Loch Bharabhat (Source: Lomax & Edwards, 2000)



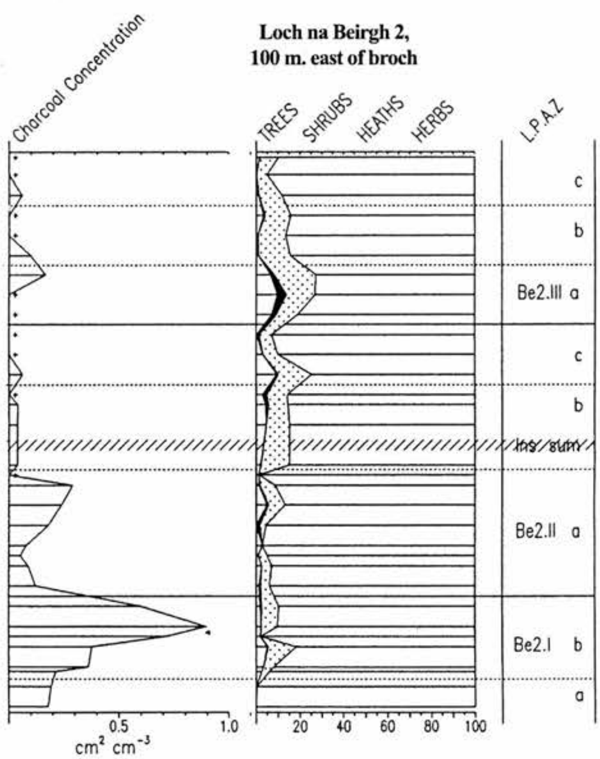


Figure 4.4a: Summary pollen diagrams from Loch na Beirgh (Source: Lomax, 1997)

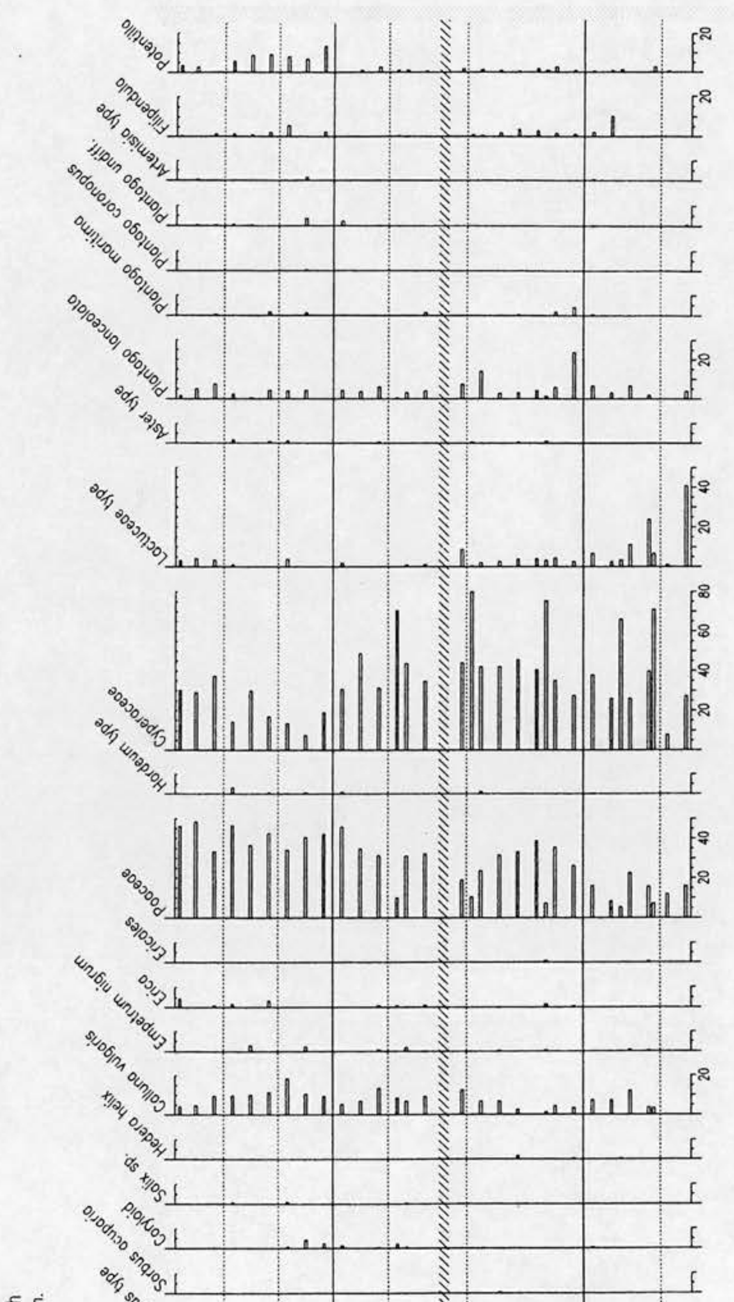


Figure 4.4b: Detailed pollen diagram from Loch na Beirgh 2 (Source: Lomax, 1997)

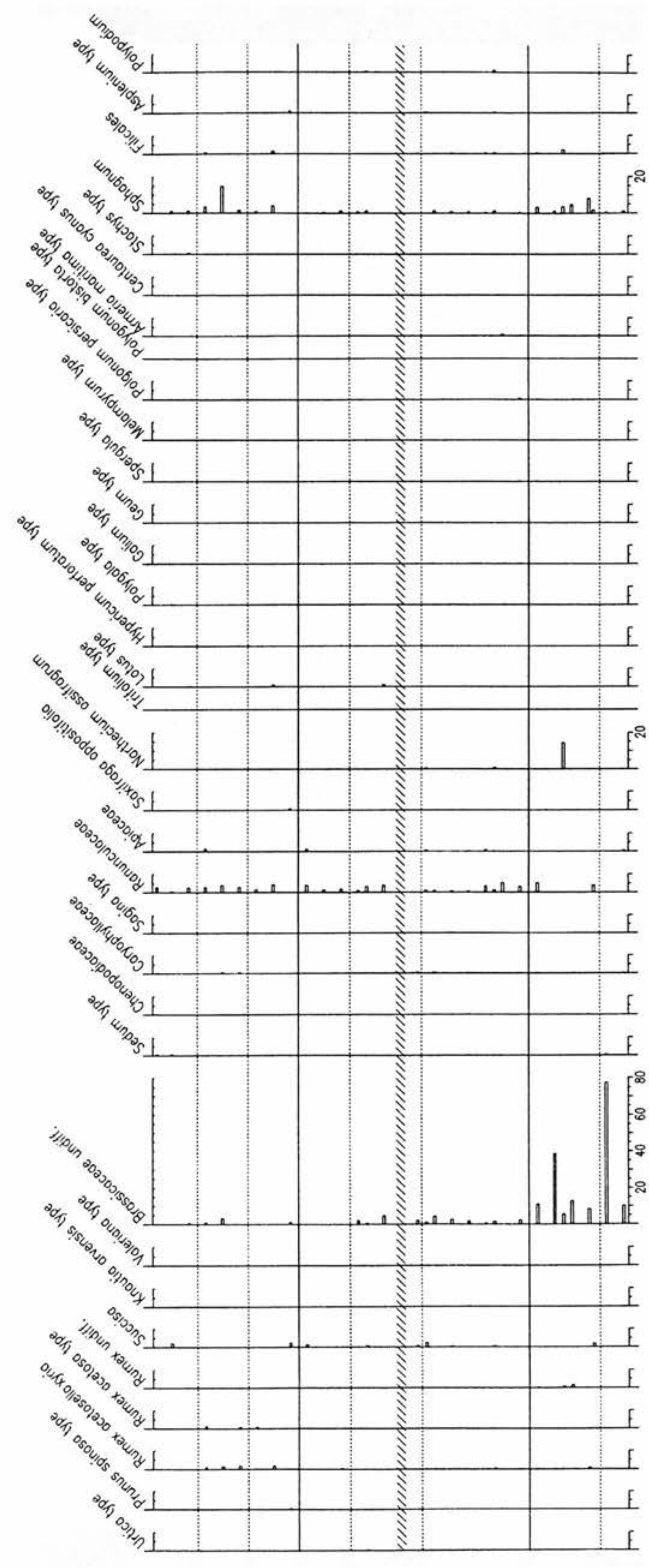


Figure 4.4b: Detailed pollen diagram from Loch na Beirgh 2 continued (Source: Lomax, 1997)

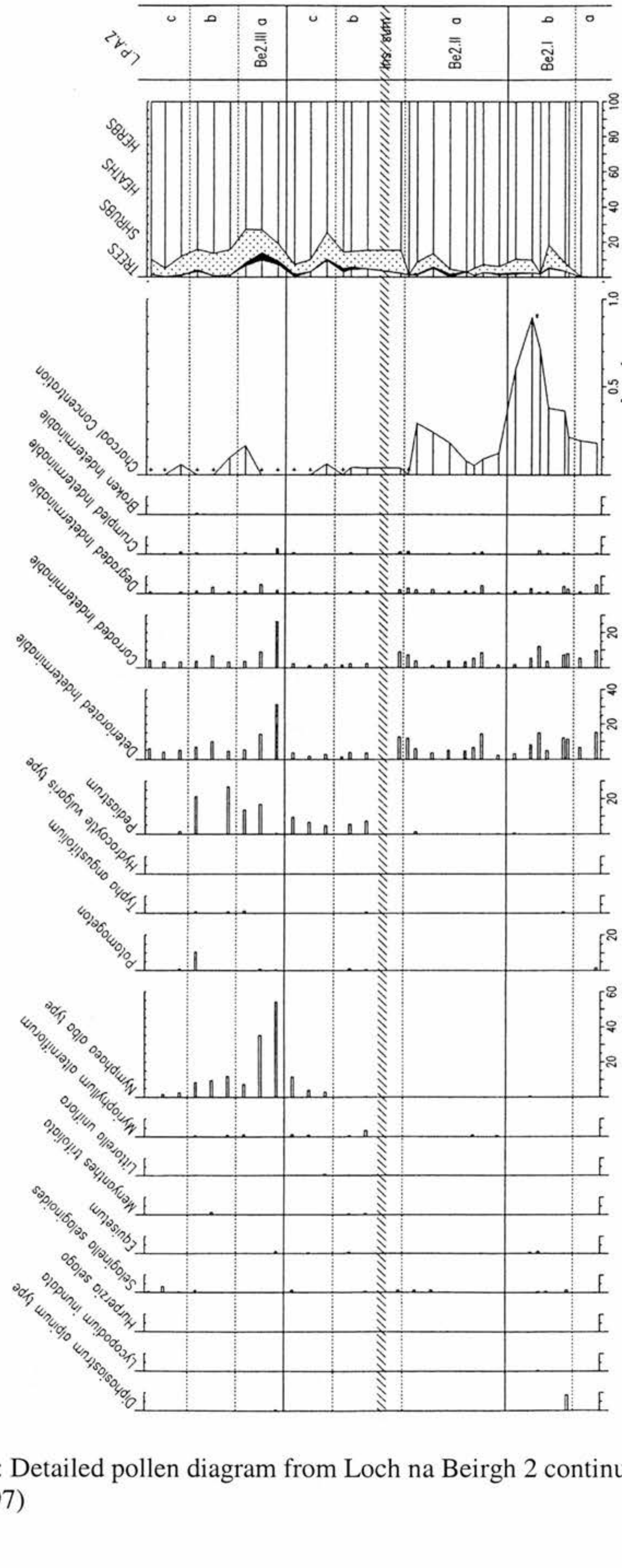


Figure 4.4b: Detailed pollen diagram from Loch na Beirgh 2 continued (Source: Lomax, 1997)

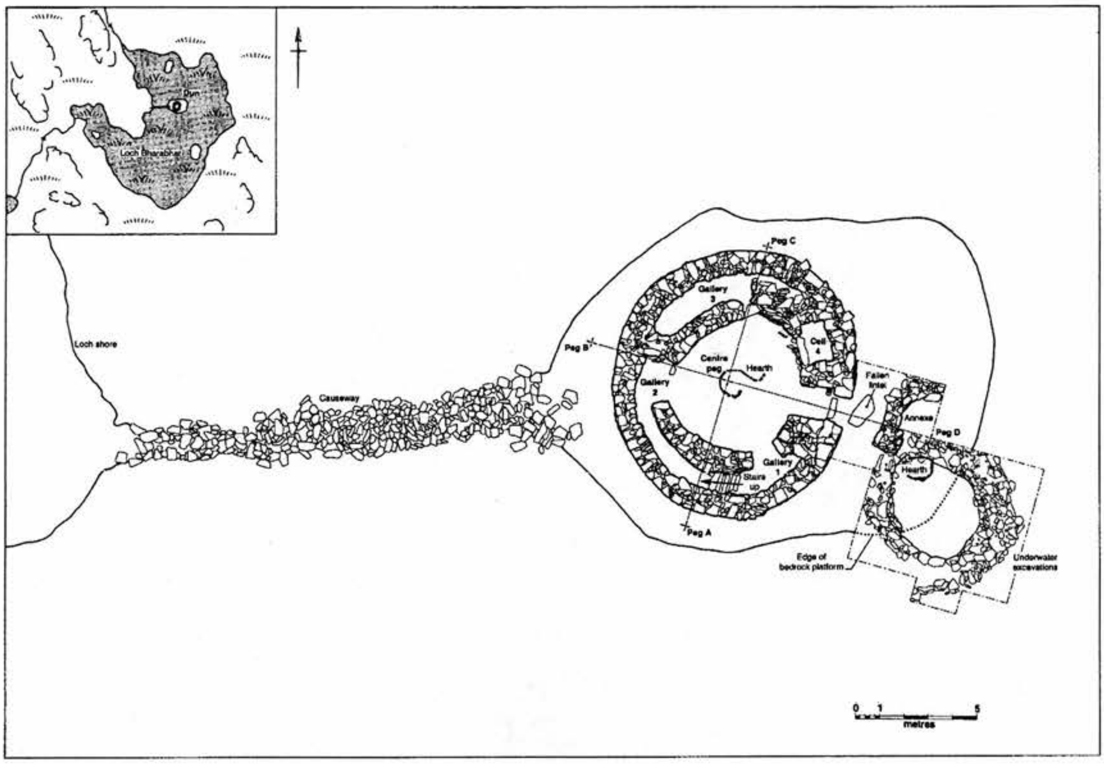


Figure 4.5: Plan of excavations at Dun Bharabhat (Source: Harding & Dixon, 2000)

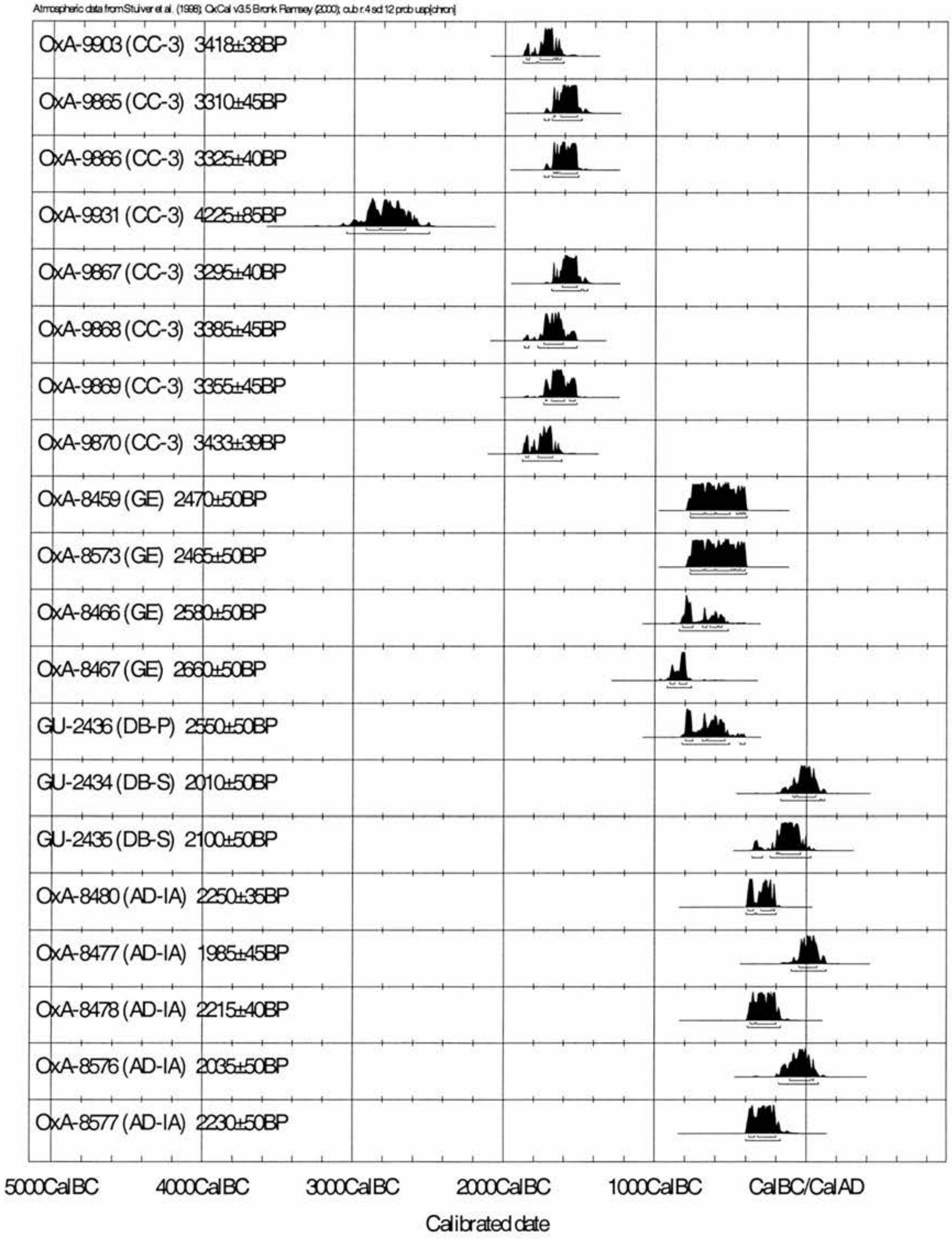


Figure 4.6a: Calibrated radiocarbon dates from archaeological sites (see Table 4.1 for details on individual dates and 'Conventions and abbreviations' in Contents for site block abbreviations)

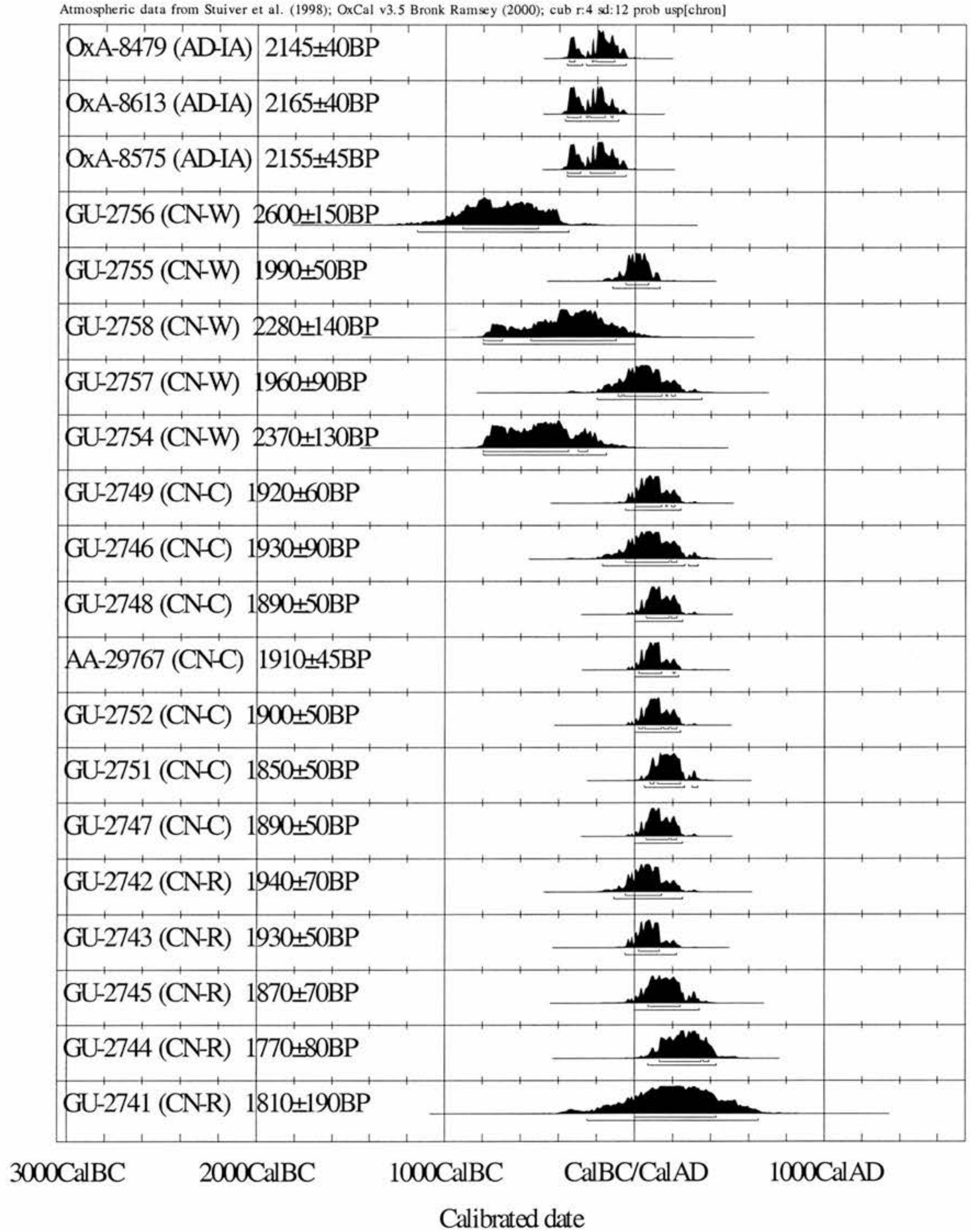


Figure 4.6b: Calibrated radiocarbon dates from archaeological sites (see Table 4.1 for details on individual dates and 'Conventions and abbreviations' in Contents for site block abbreviations)

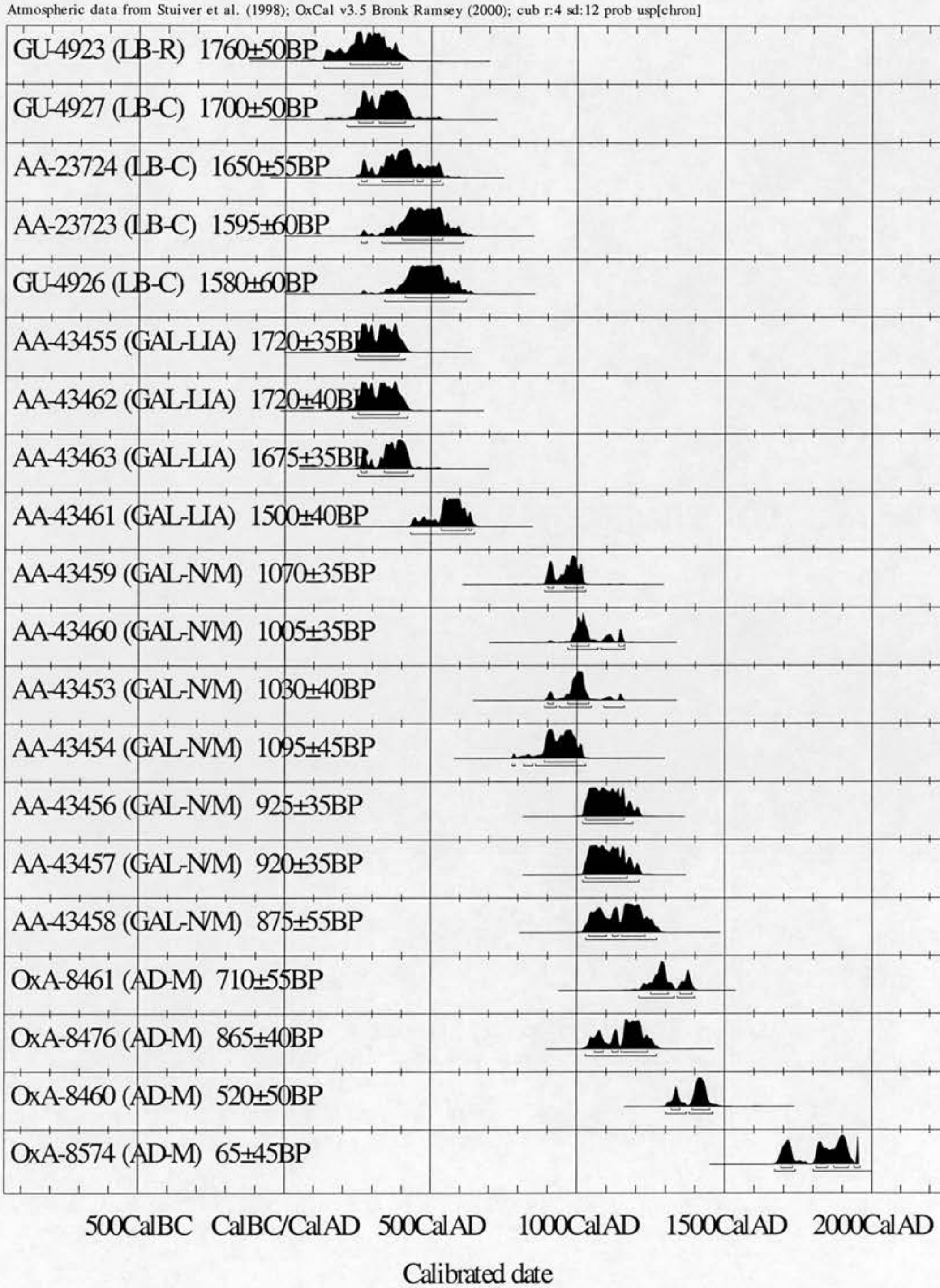


Figure 4.6c: Calibrated radiocarbon dates from archaeological sites (see Table 4.1 for details on individual dates and 'Conventions and abbreviations' in Contents for site block abbreviations)

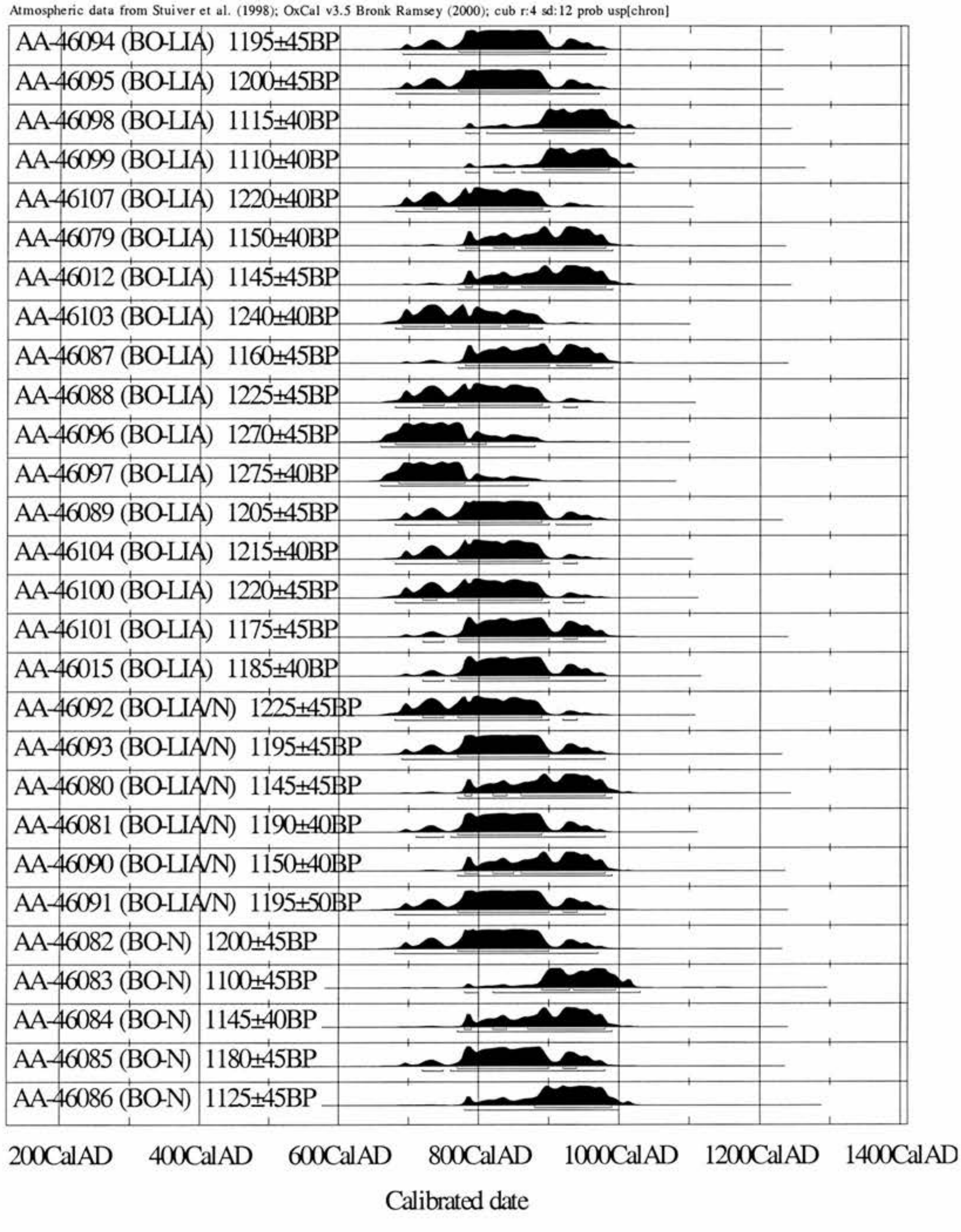


Figure 4.6d: Calibrated radiocarbon dates from Bostadh in stratigraphic order (see Table 4.1 for details on individual dates and 'Conventions and abbreviations' in Contents for site block abbreviations)

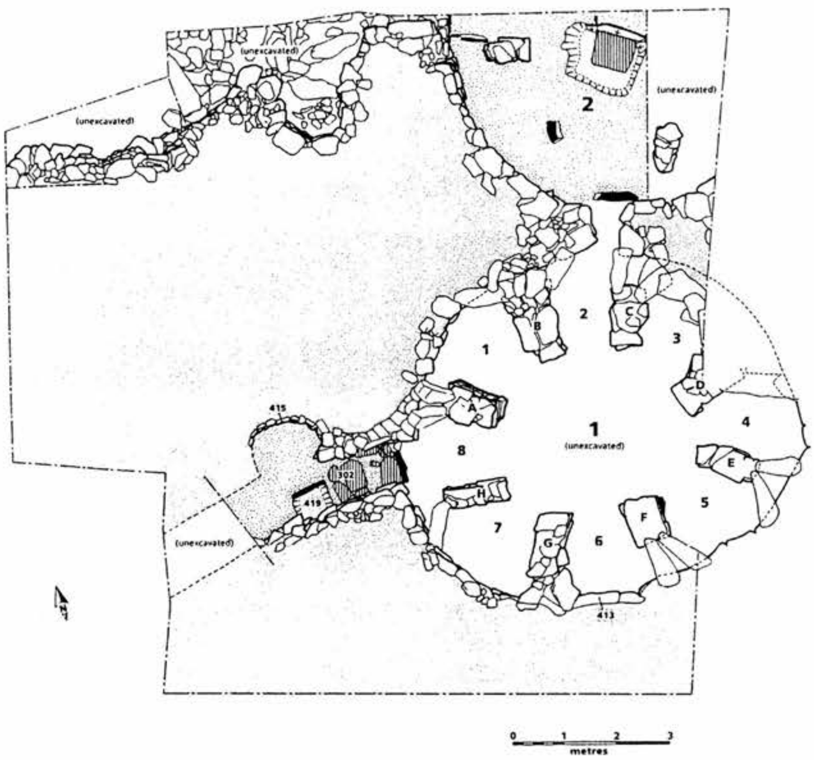


Figure 4.7: Plan of Cnip Wheelhouse block; **CN-W** (Source: Armit, forth.a)

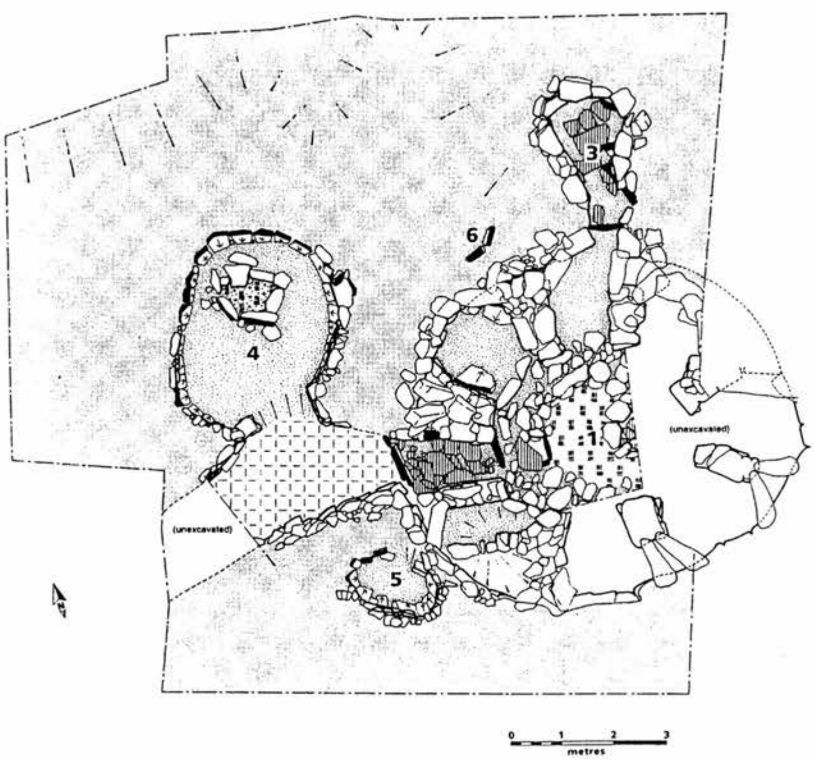


Figure 4.8: Plan of Cnip Cellular block; **CN-C** (Source: Armit, forth.a)

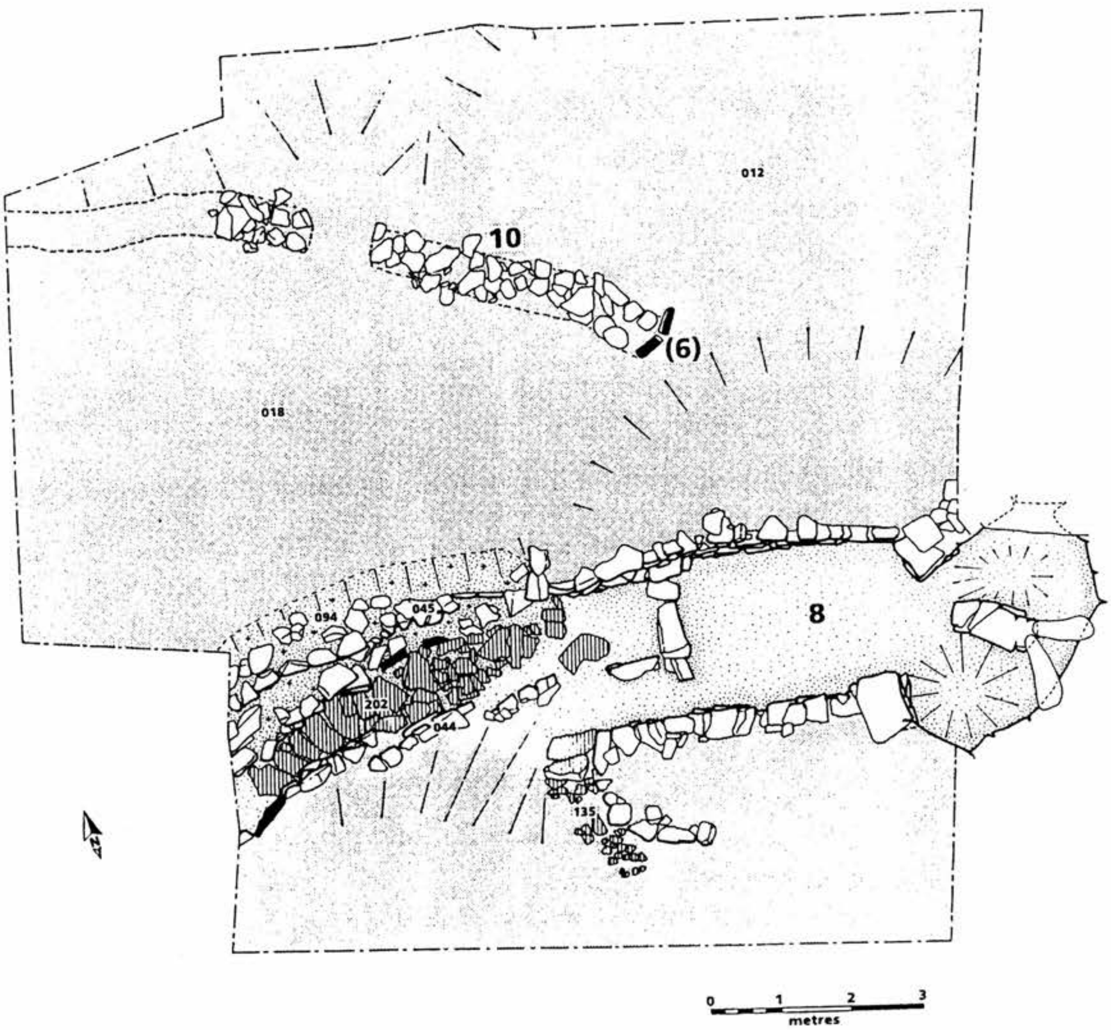


Figure 4.9: Plan of Cnip Rectilinear block; **CN-R** (Source: Armit, forth.a)

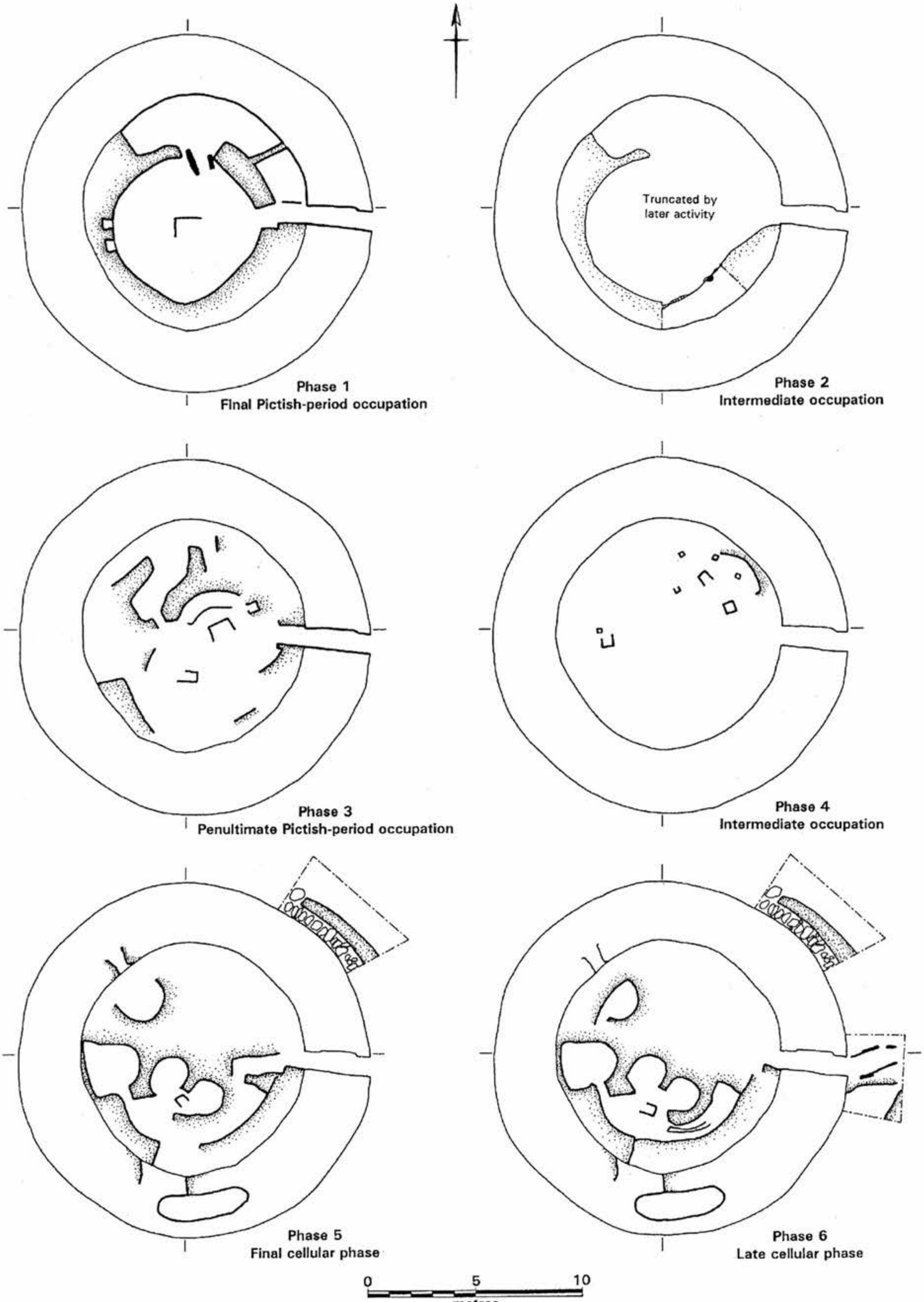
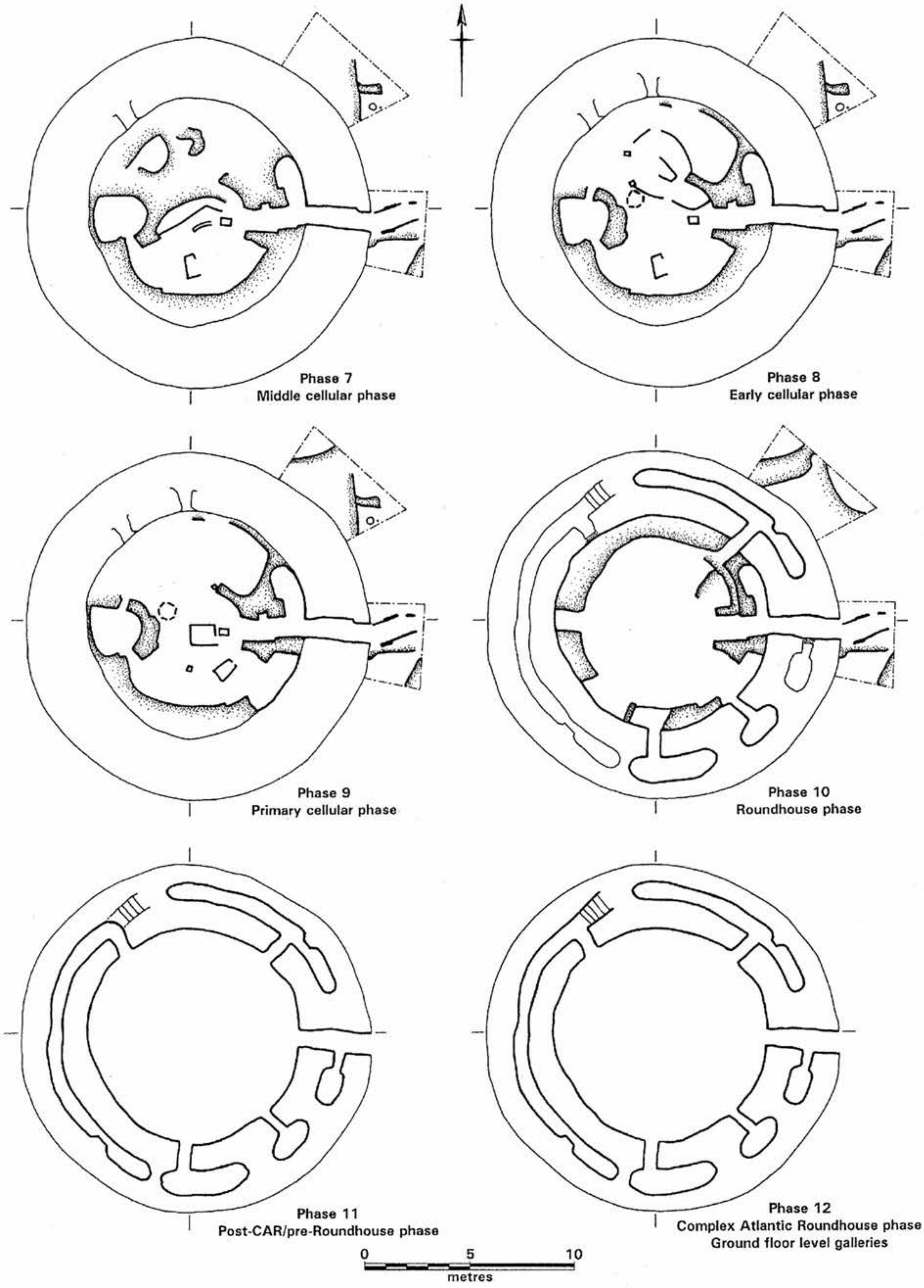


Figure 4.10a: Summary sequence from Loch na Beirgh (Source: Harding & Gilmour, 2000)

Figure 4.10b: Summary sequence from Loch na Beirgh (Source: Harding & Gilmour, 2000)



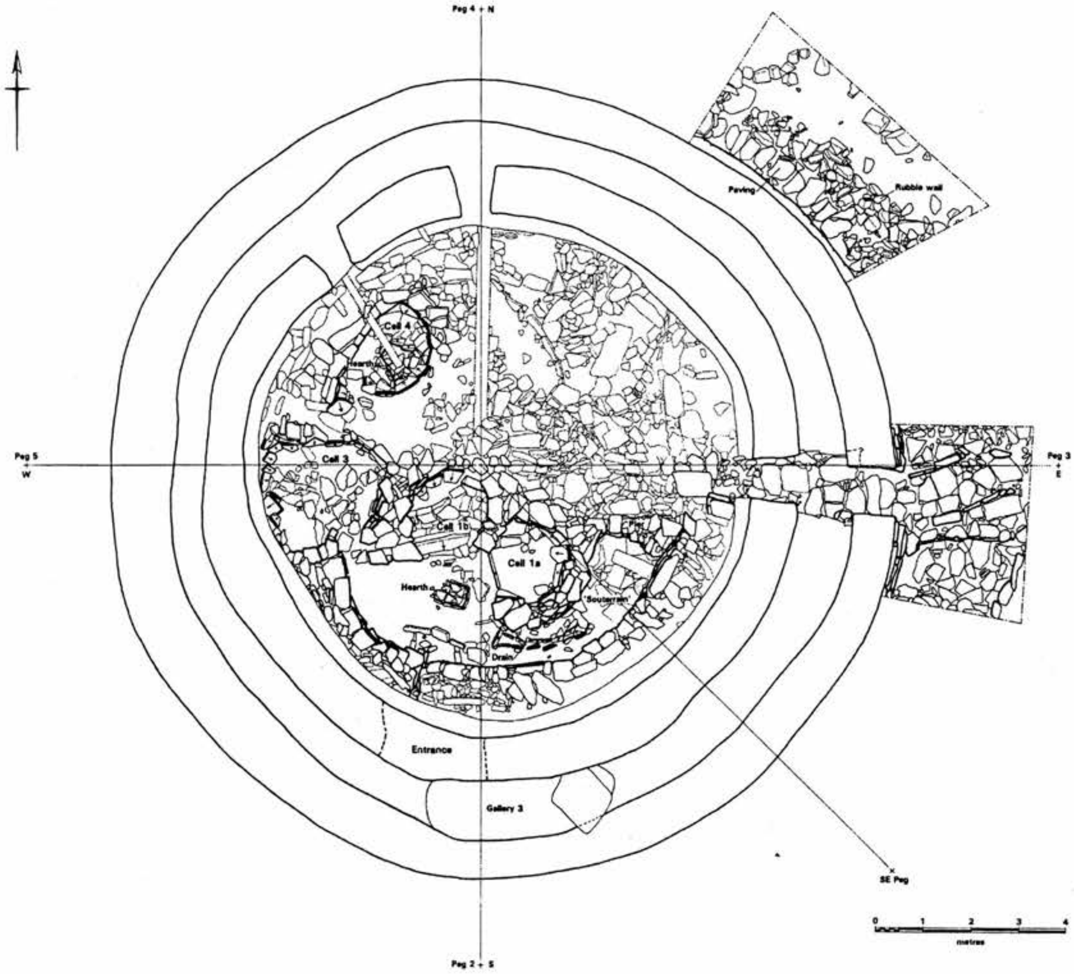


Figure 4.11: Plan of Phase 6 Cellular buildings at Loch na Beirgh (part of **LB-C**), including 'shamrock' and souterrain (Source: Harding & Gilmour, 2000)

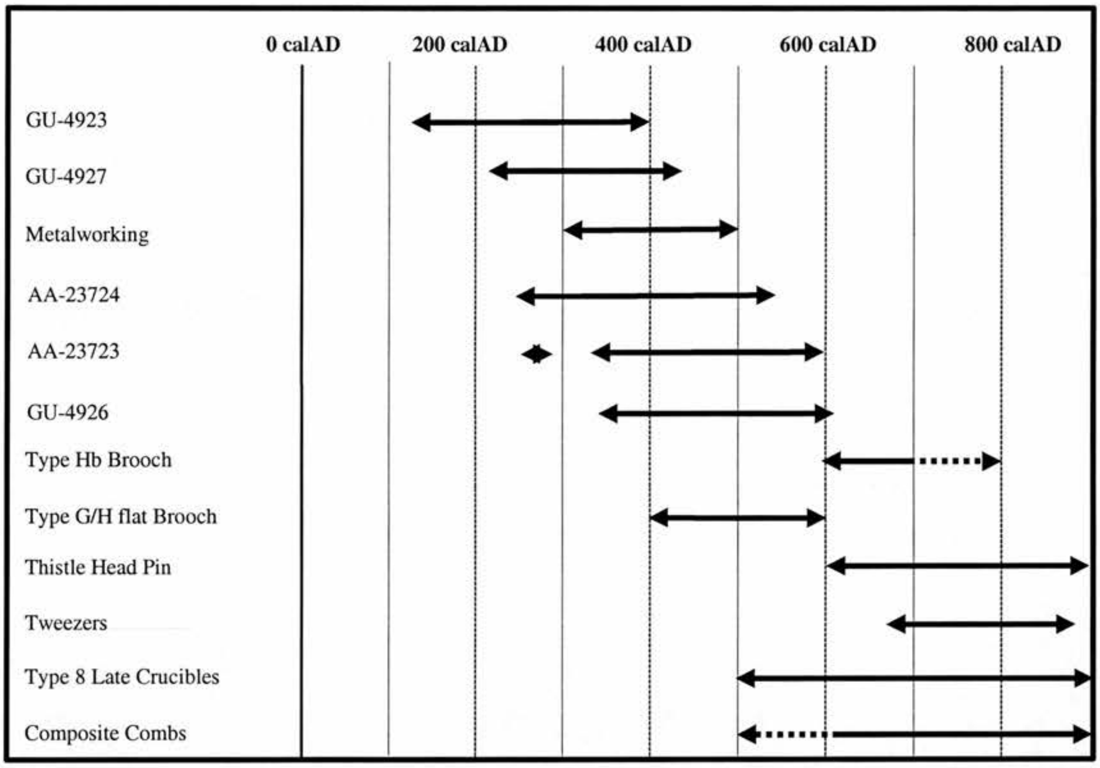


Figure 4.12: Dating sequence for Loch na Beirgh (Source: Harding & Gilmour, 2000)

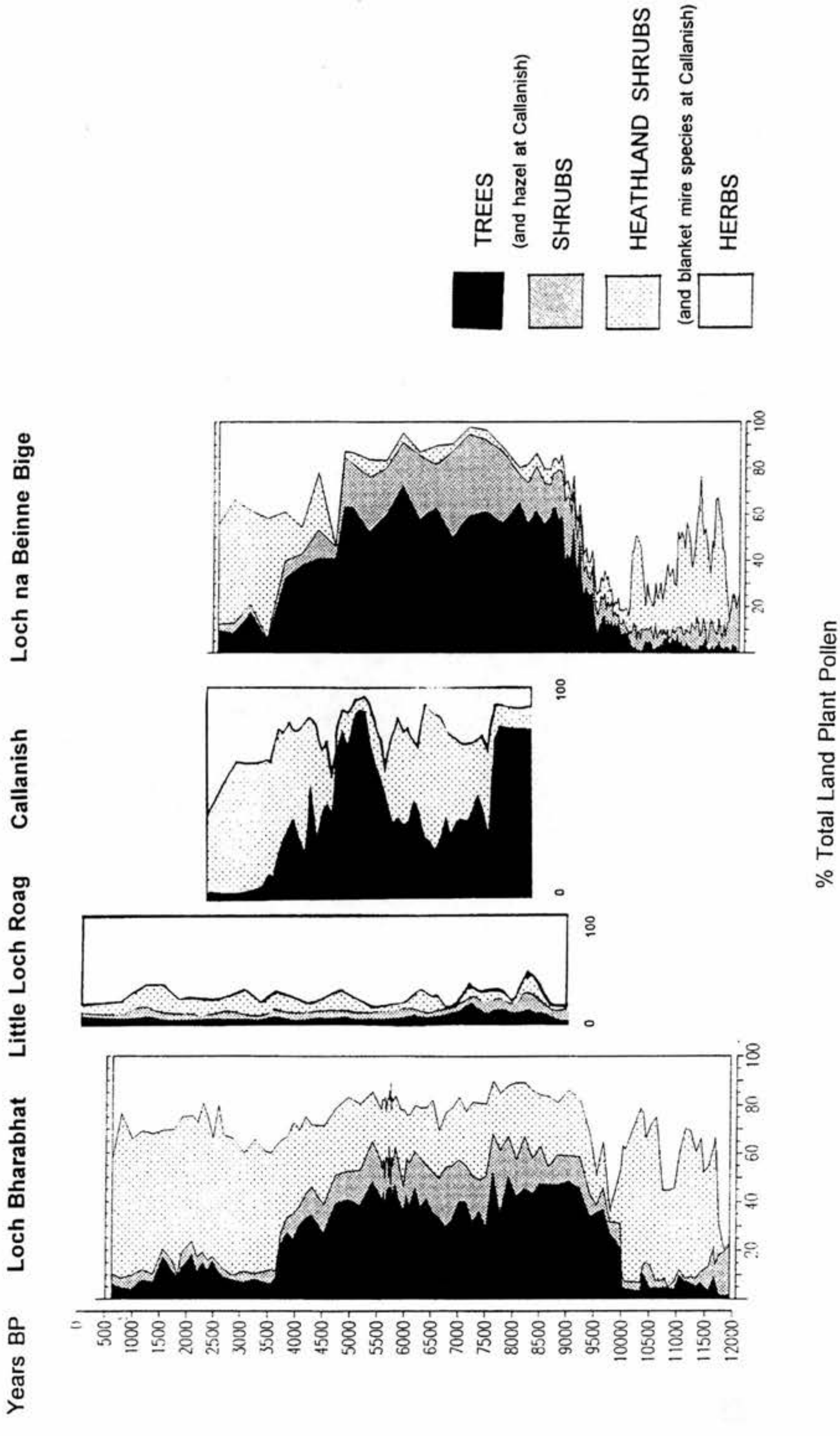


Figure 4.13: Pollen diagrams near Calanais (Source: Edwards *et al.*, 1994)

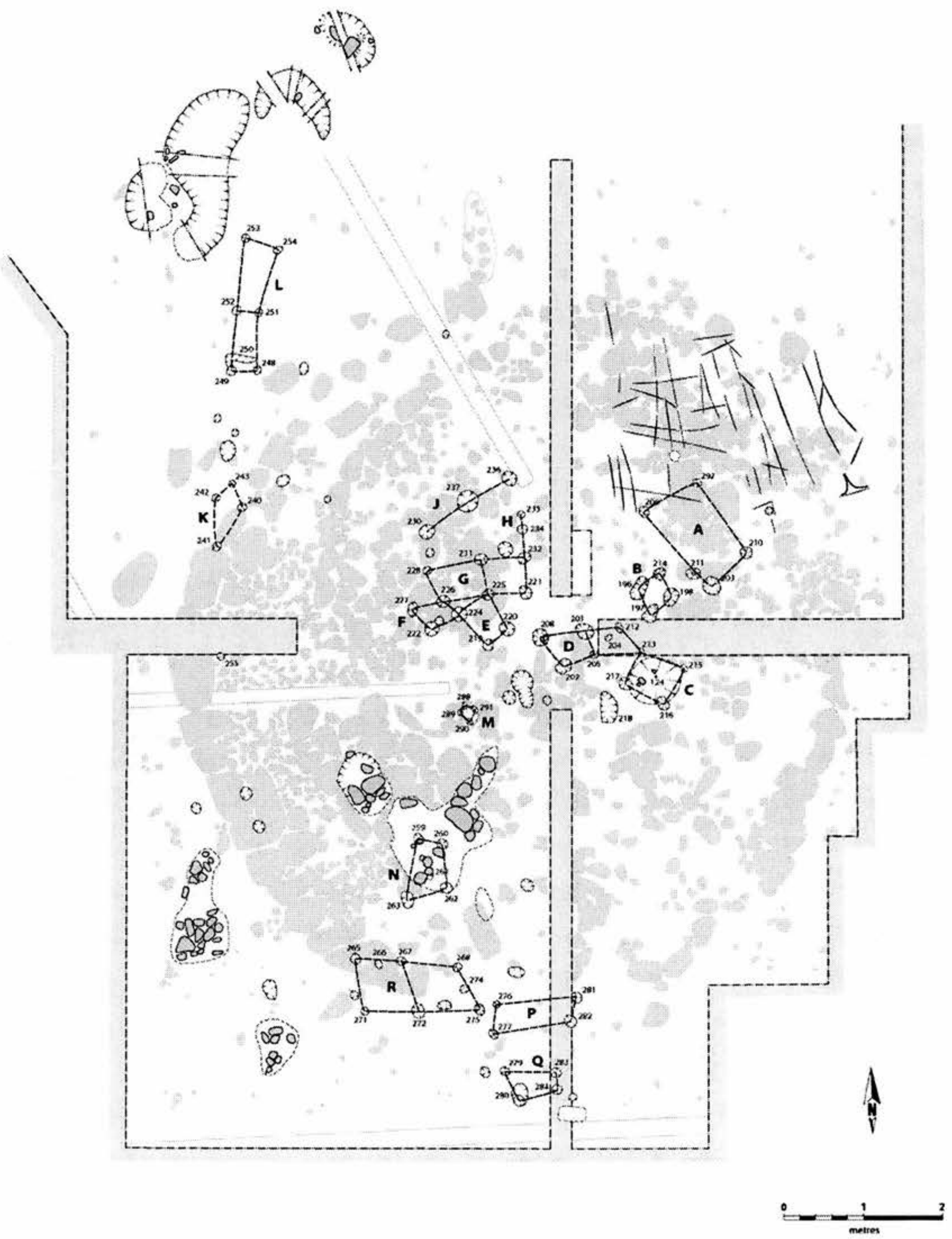


Figure 4.14: Plan of negative features underlying Calanais kerb cairn; **CC-1** (Source: Neighbour, 2001a)

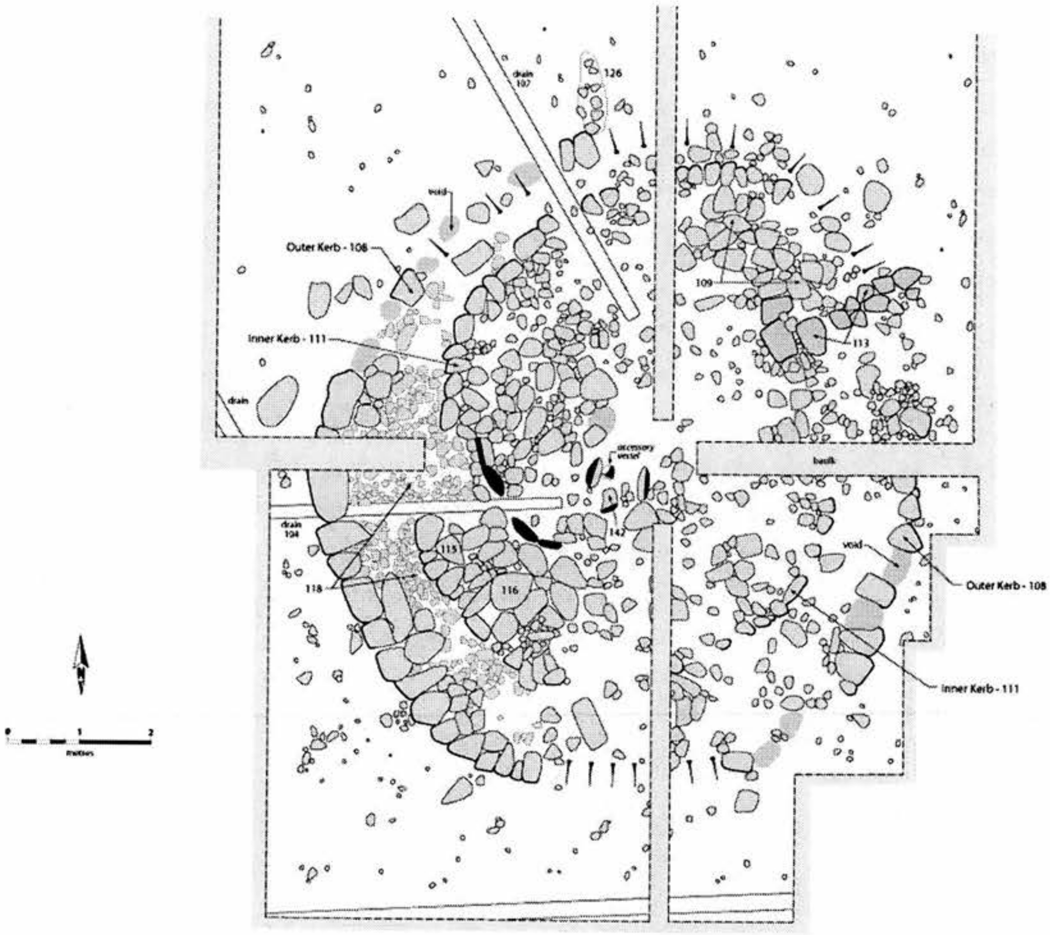
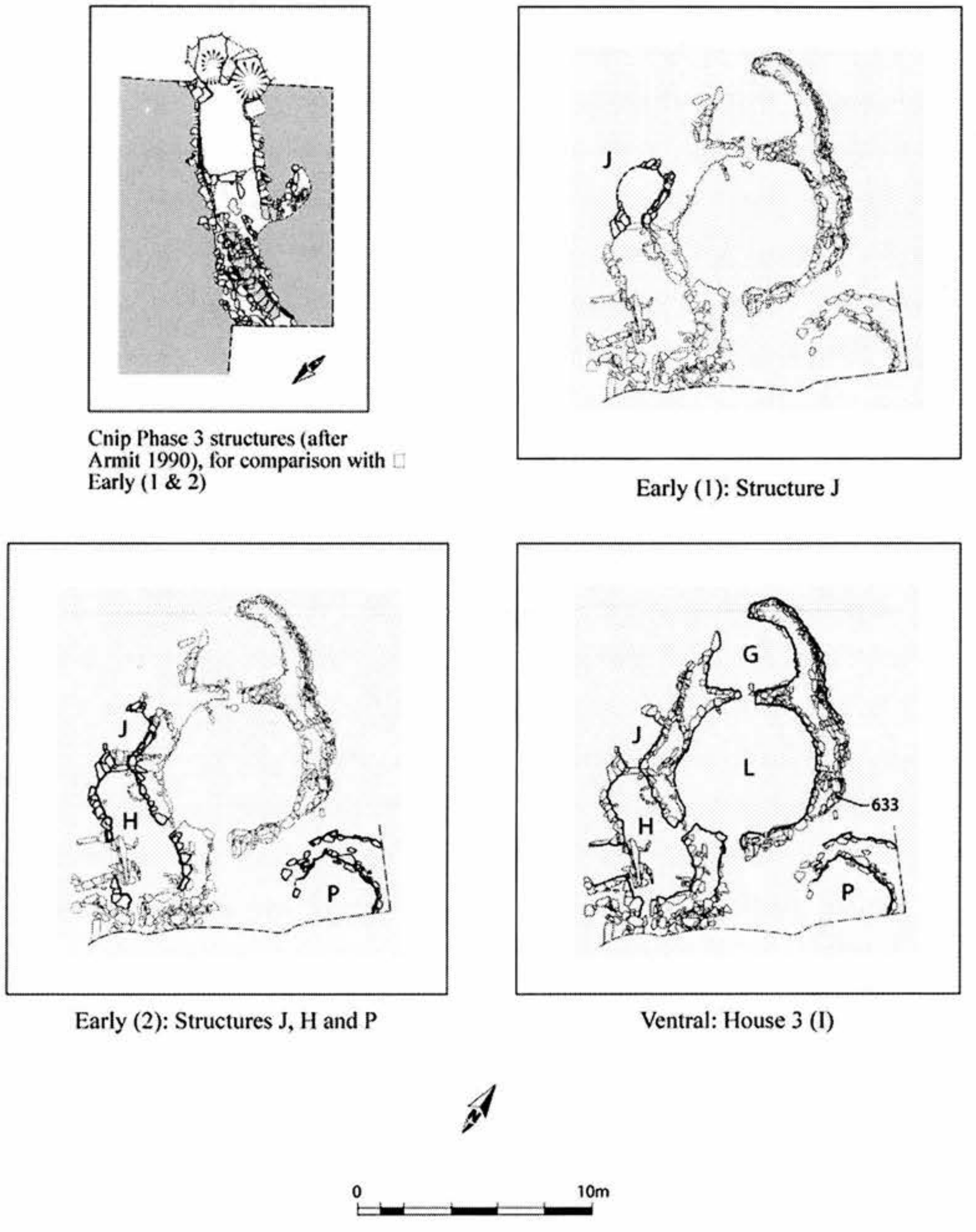


Figure 4.15: Plan of Calanais kerb cairn; **CC-3** (Source: Neighbour, 2001a)



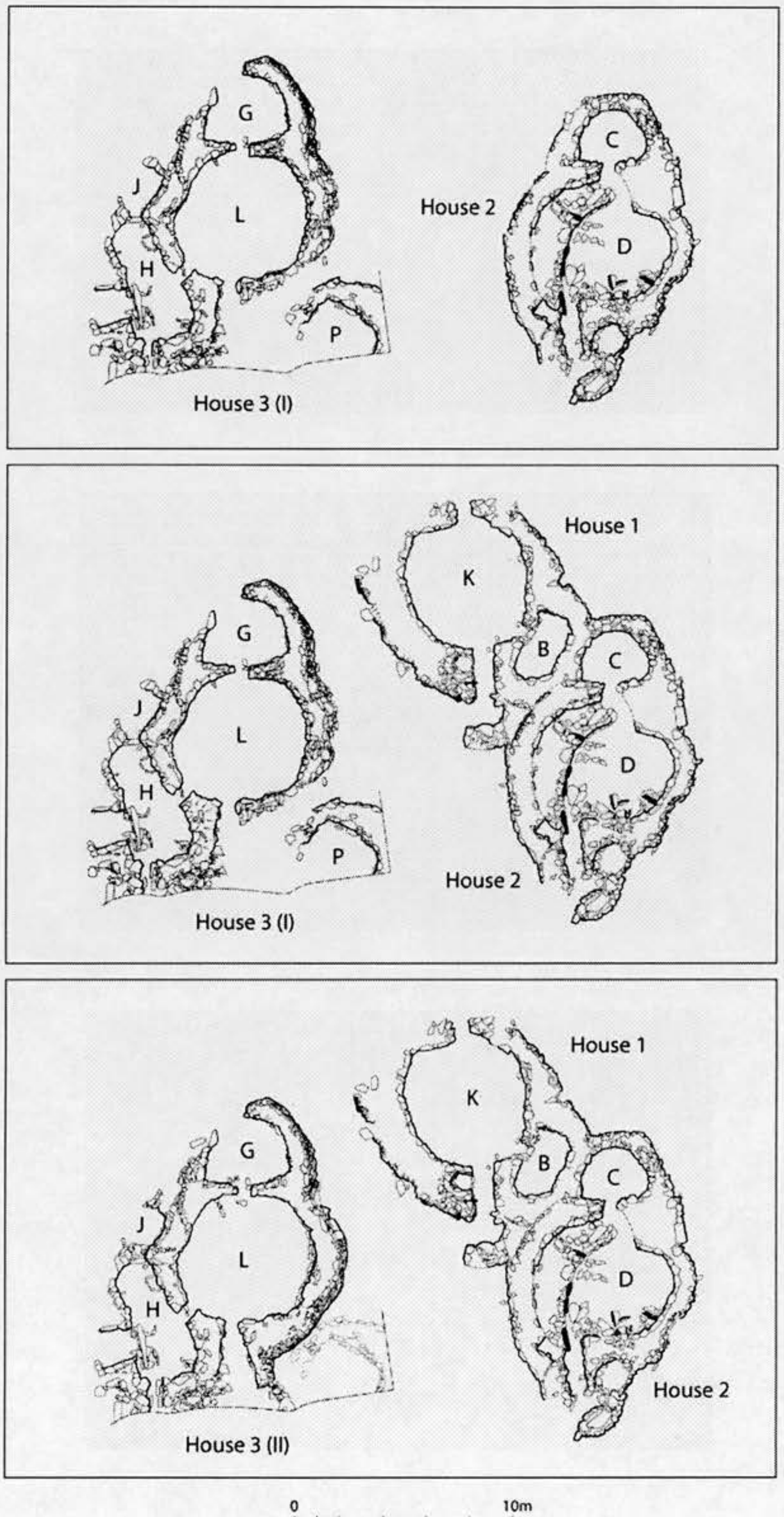
Cnip Phase 3 structures (after Armit 1990), for comparison with Early (1 & 2)

Early (1): Structure J

Early (2): Structures J, H and P

Ventral: House 3 (I)

Figure 4.16a: The evolution of the settlement at Bostadh (Source: Neighbour, 2001b)



Ventral: House 3(I) and House 2

Ventral: House 3(I) and Houses 1 & 2

Ventral: House 3(II) and Houses 1 & 2

Figure 4.16b: The evolution of the settlement at Bostadh (Source: Neighbour, 2001b)

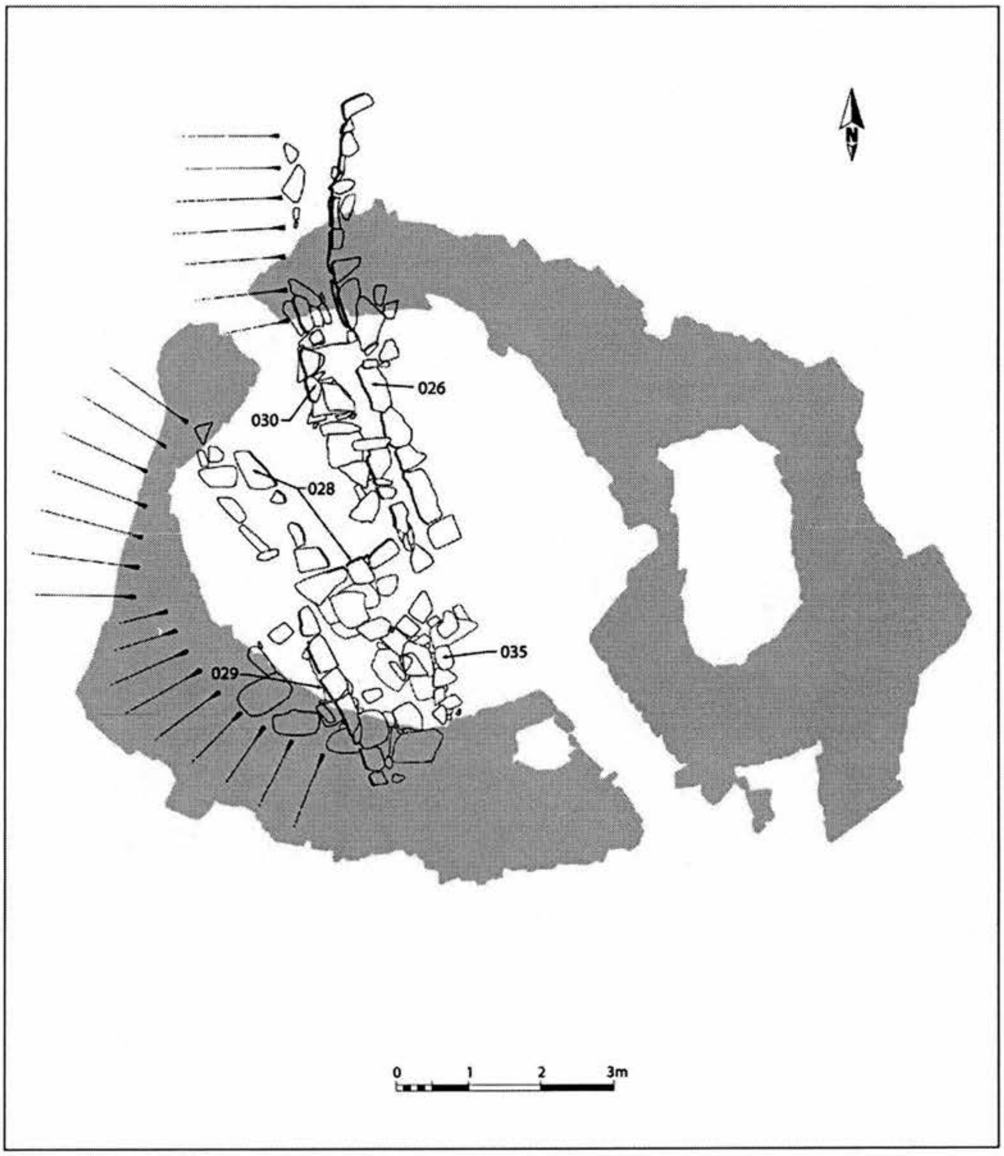


Figure 4.17: The Norse building at Bostadh (**BO-N**) with underlying Late Iron Age House shown in grey (Source: Neighbour, 2001b)

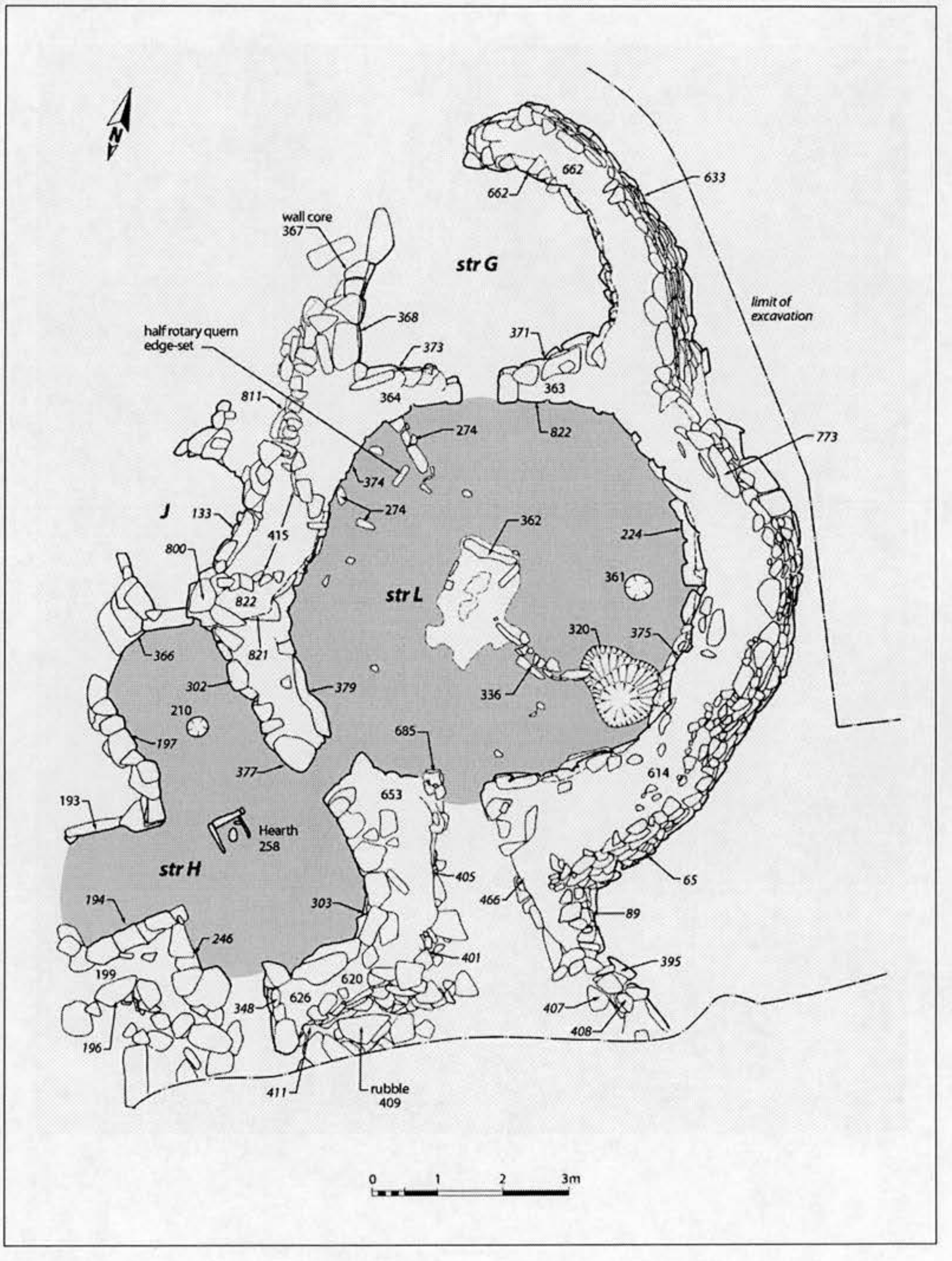


Figure 4.18: Bostadh House 3 occupation features; **BO-LIA** (Source: Neighbour, 2001b)

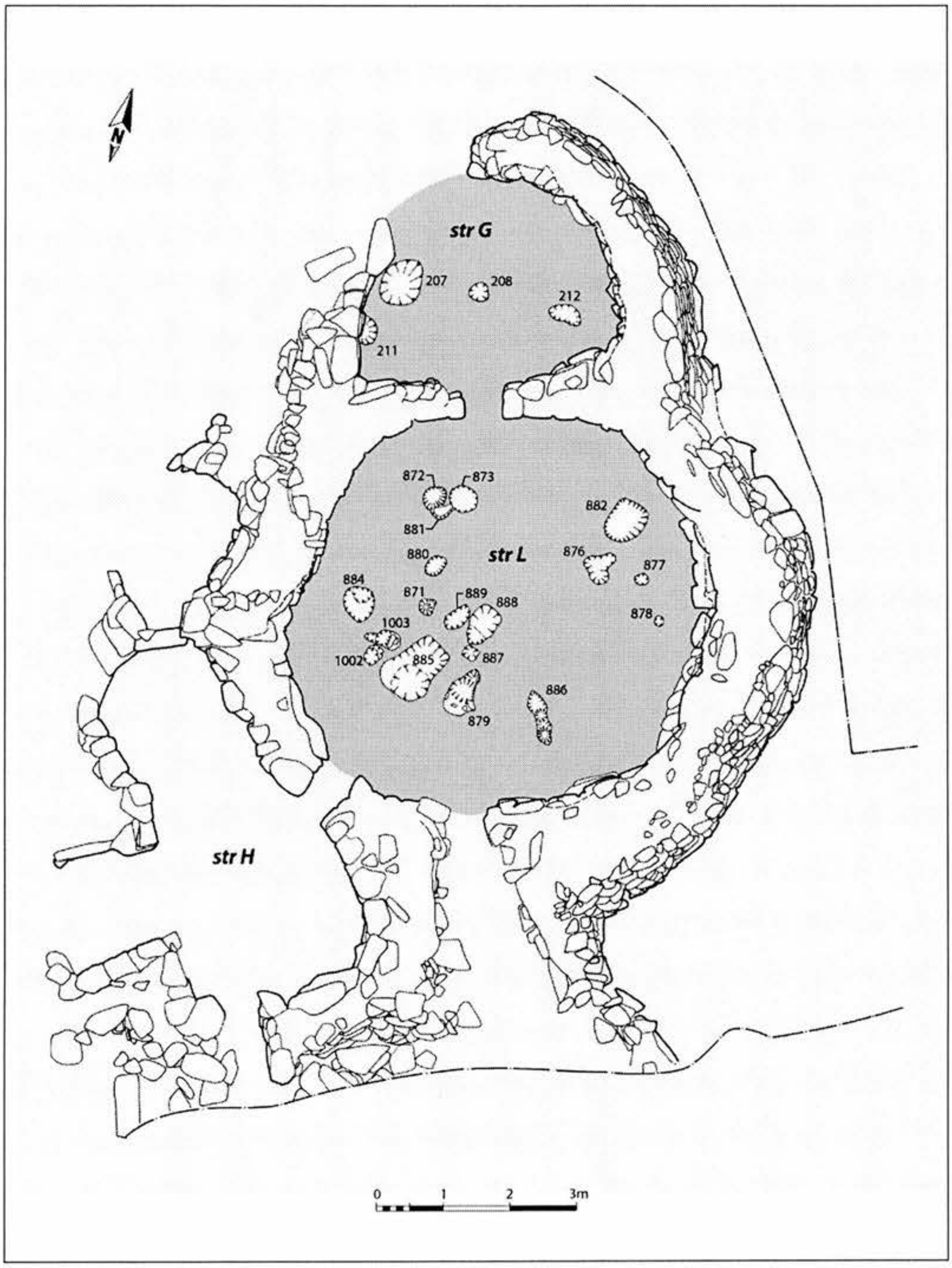


Figure 4.19: Bostadh House 3 pre-floor pits; **BO-LIA** (Source: Neighbour, 2001b)

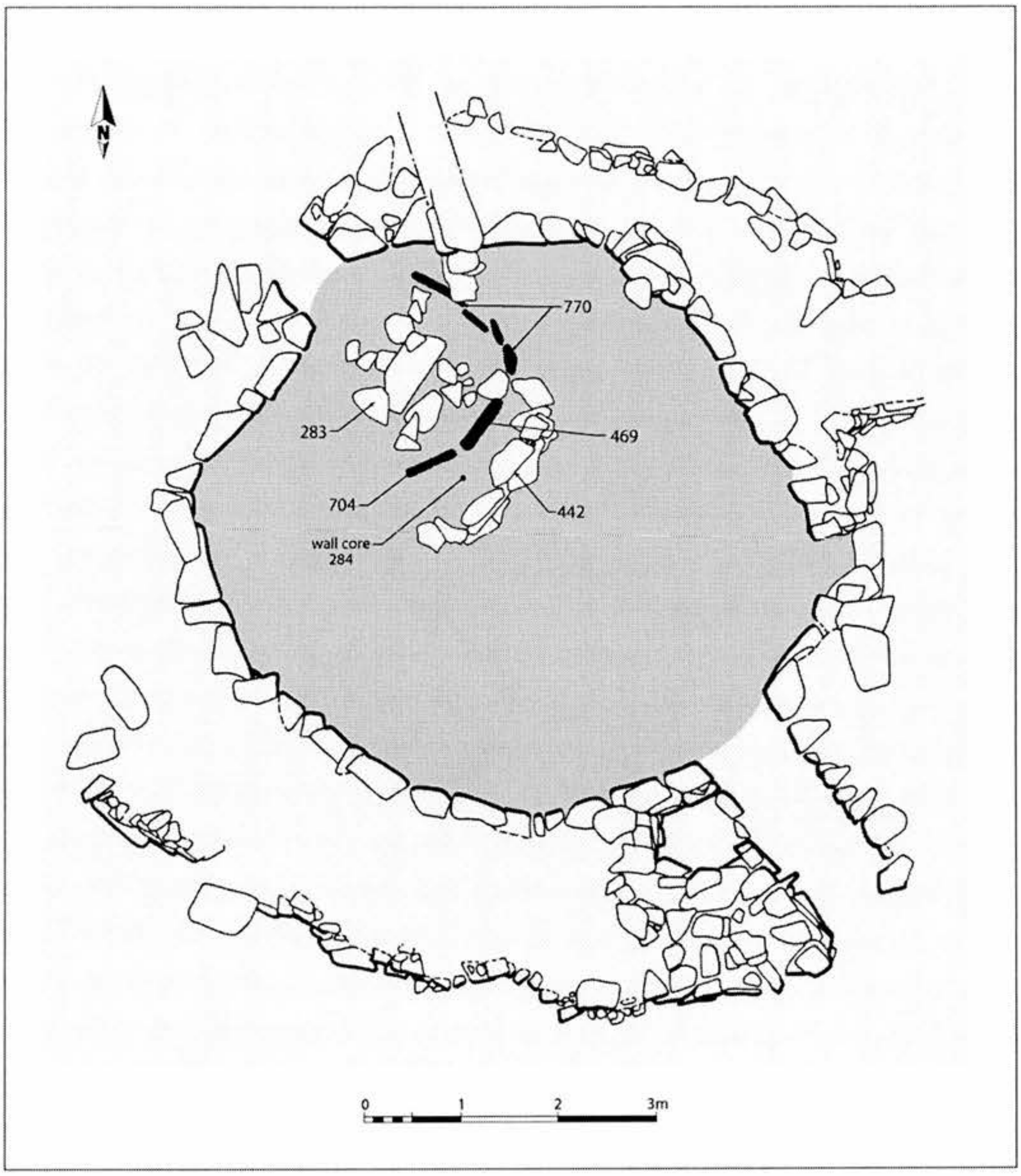


Figure 4.20: Bostadh Structure M within House 1; **BO-LIA/N** (Source: Neighbour, 2001b)

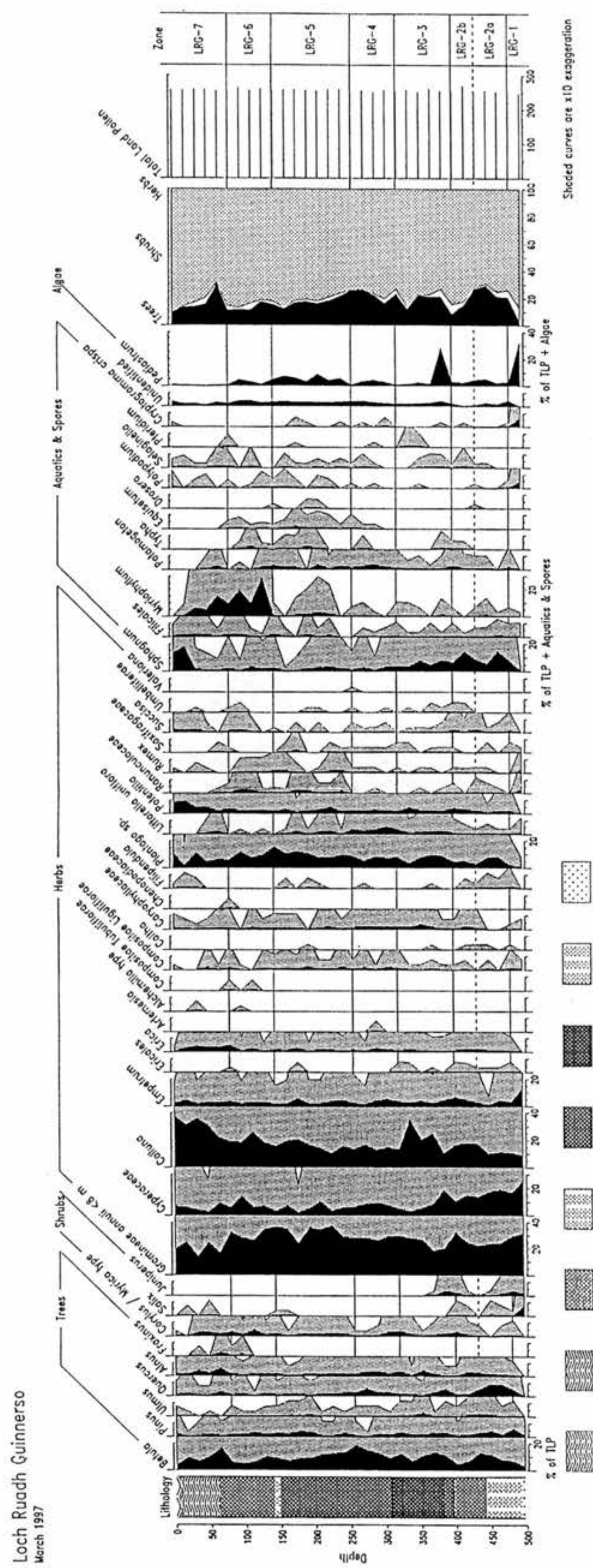


Figure 4.21: Summary pollen diagram from Loch Ruadh Guinnerso (Source: Flitcroft, 1997)

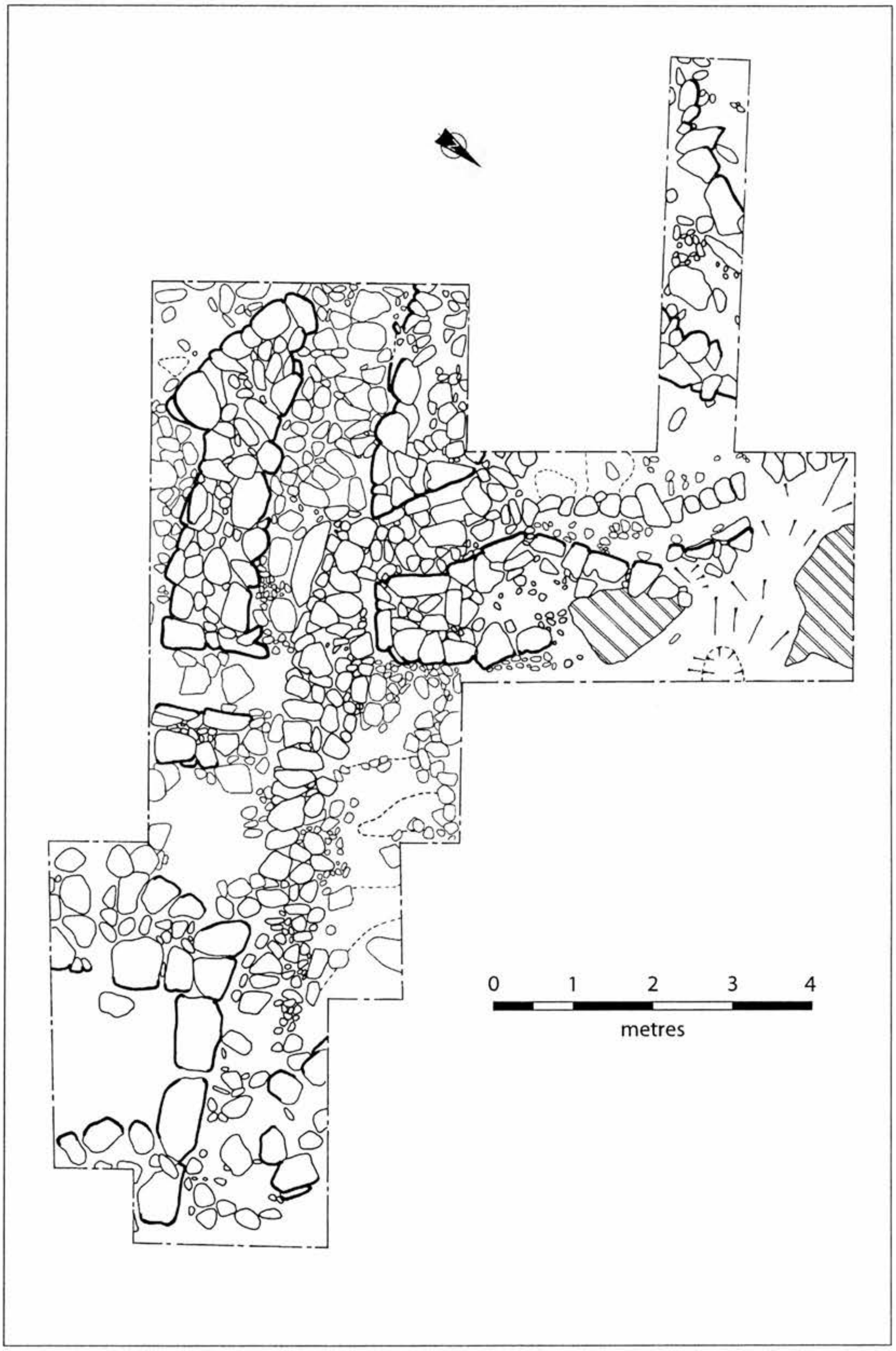


Figure 4.22: Plan of main phase at Gob Eirer (**GE**)

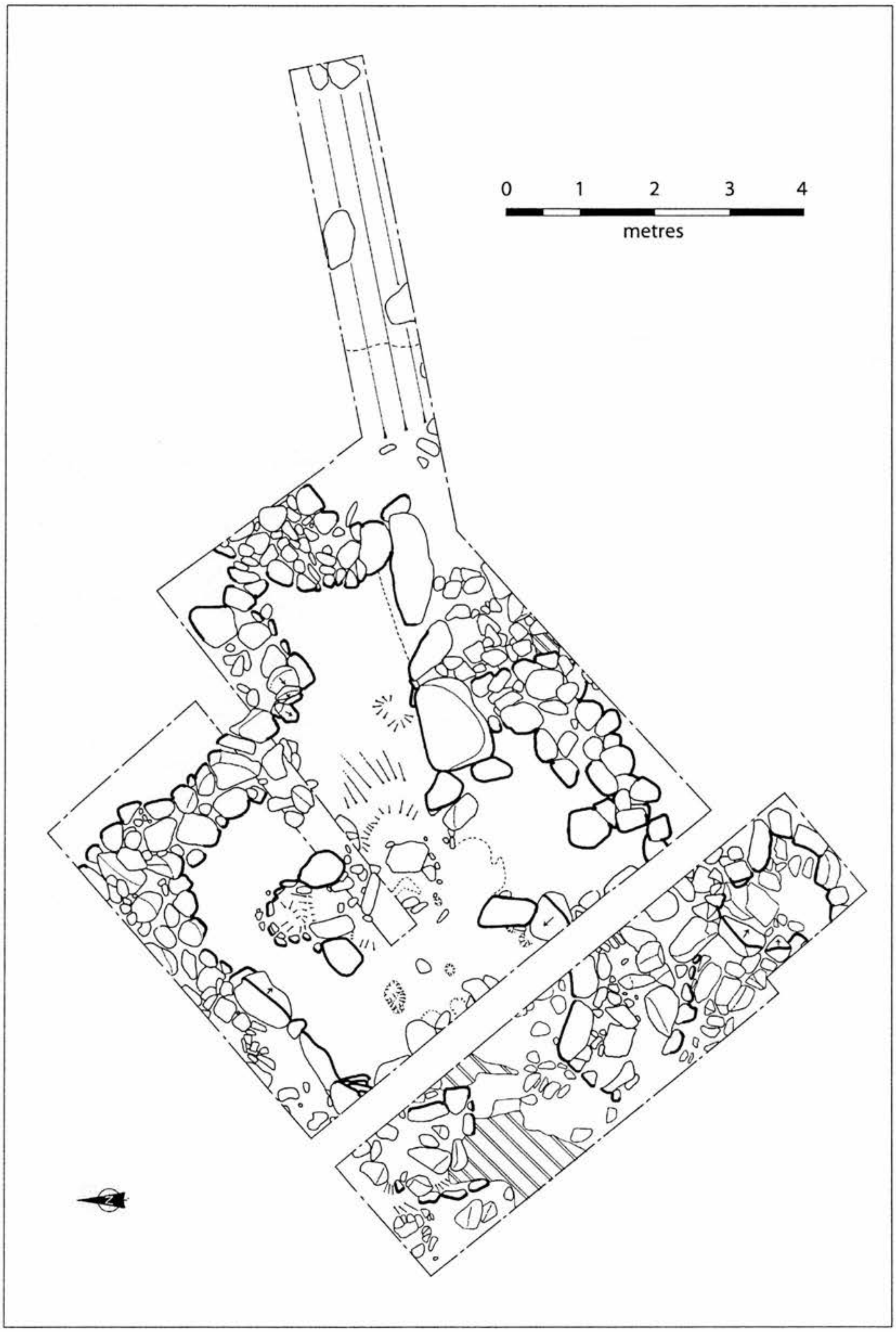


Figure 4.23: Plan of Iron Age possible funerary structure at An Dunan (**AD-IA**)

Figure 4.24: View of features comprising Iron Age block at Guinnerso (**GUN**)

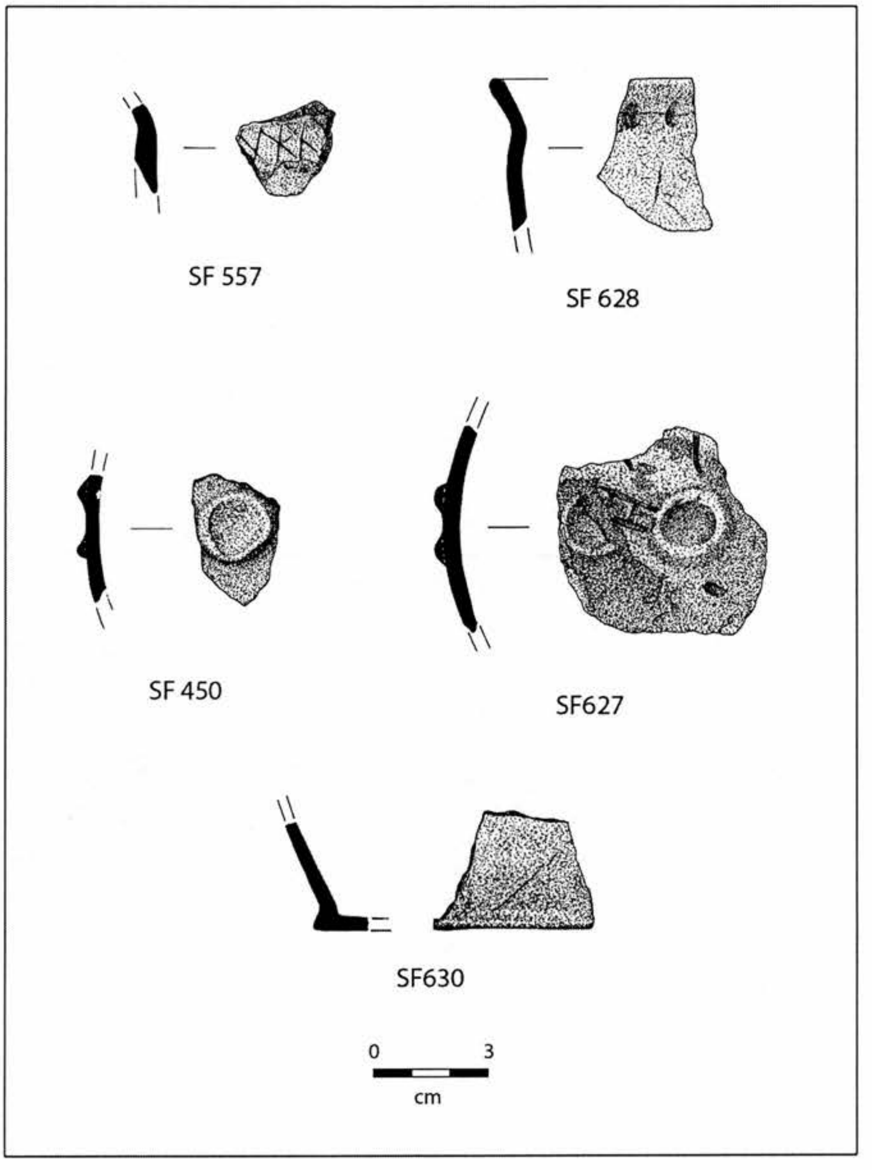


Figure 4.25: Diagnostic pottery forms from Iron Age block at Guinnerso (**GUN**)

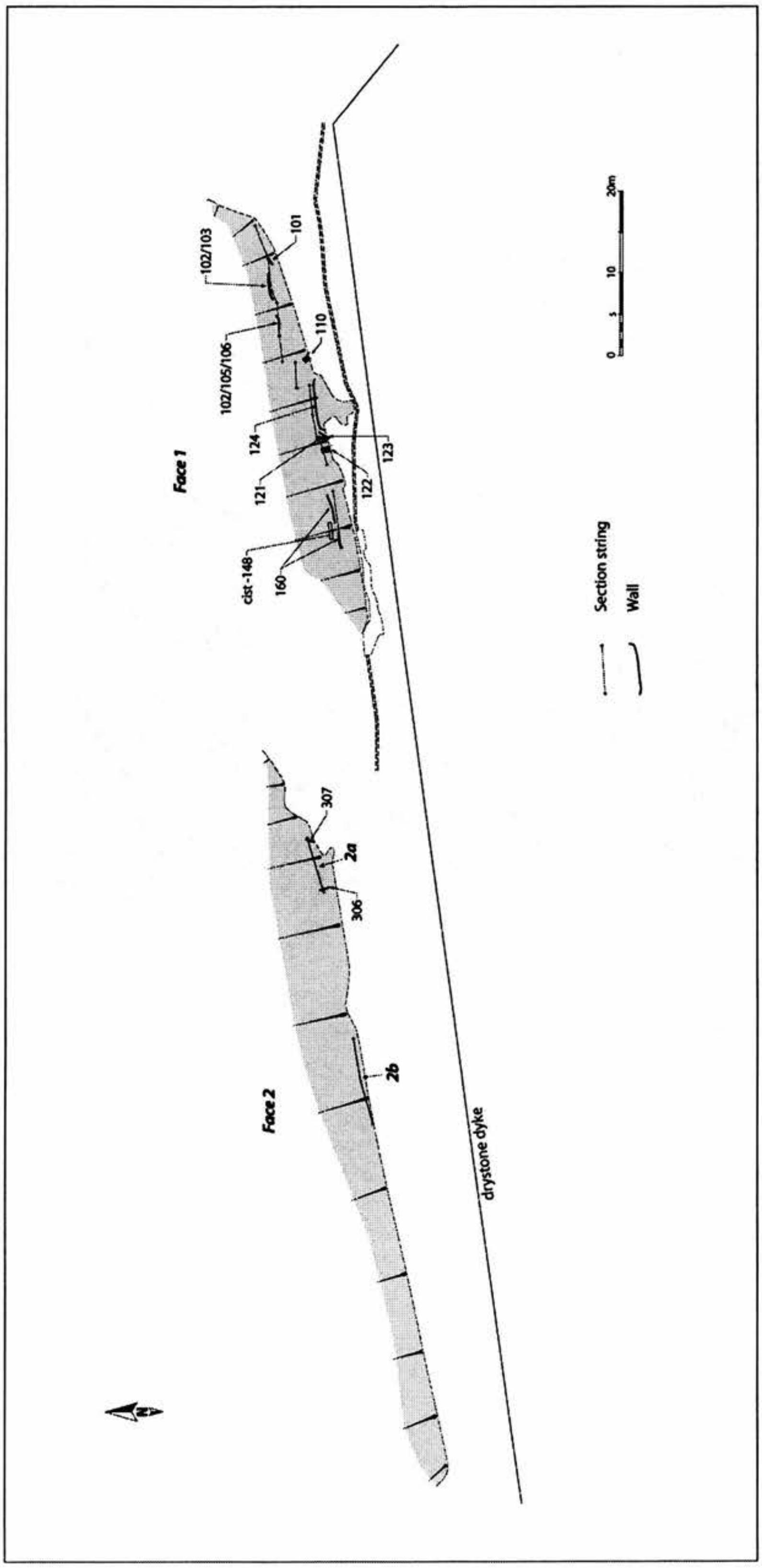


Figure 4.26: Plan of erosion face at Galson (Source: Neighbour & Church, 2001)

Figure 4.27a: Section of eroding face 1 at Galson (Source: Neighbour & Church, 2001)

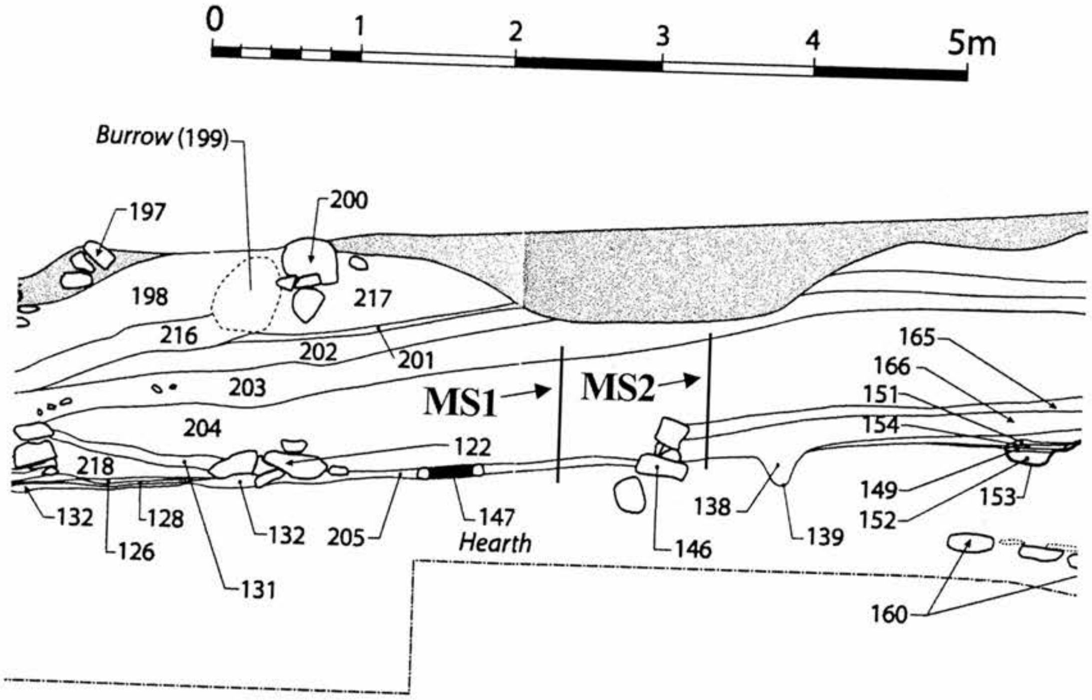


Figure 4.27b: Section of Structural Complex B at Galson (Source: Neighbour & Church, 2001)

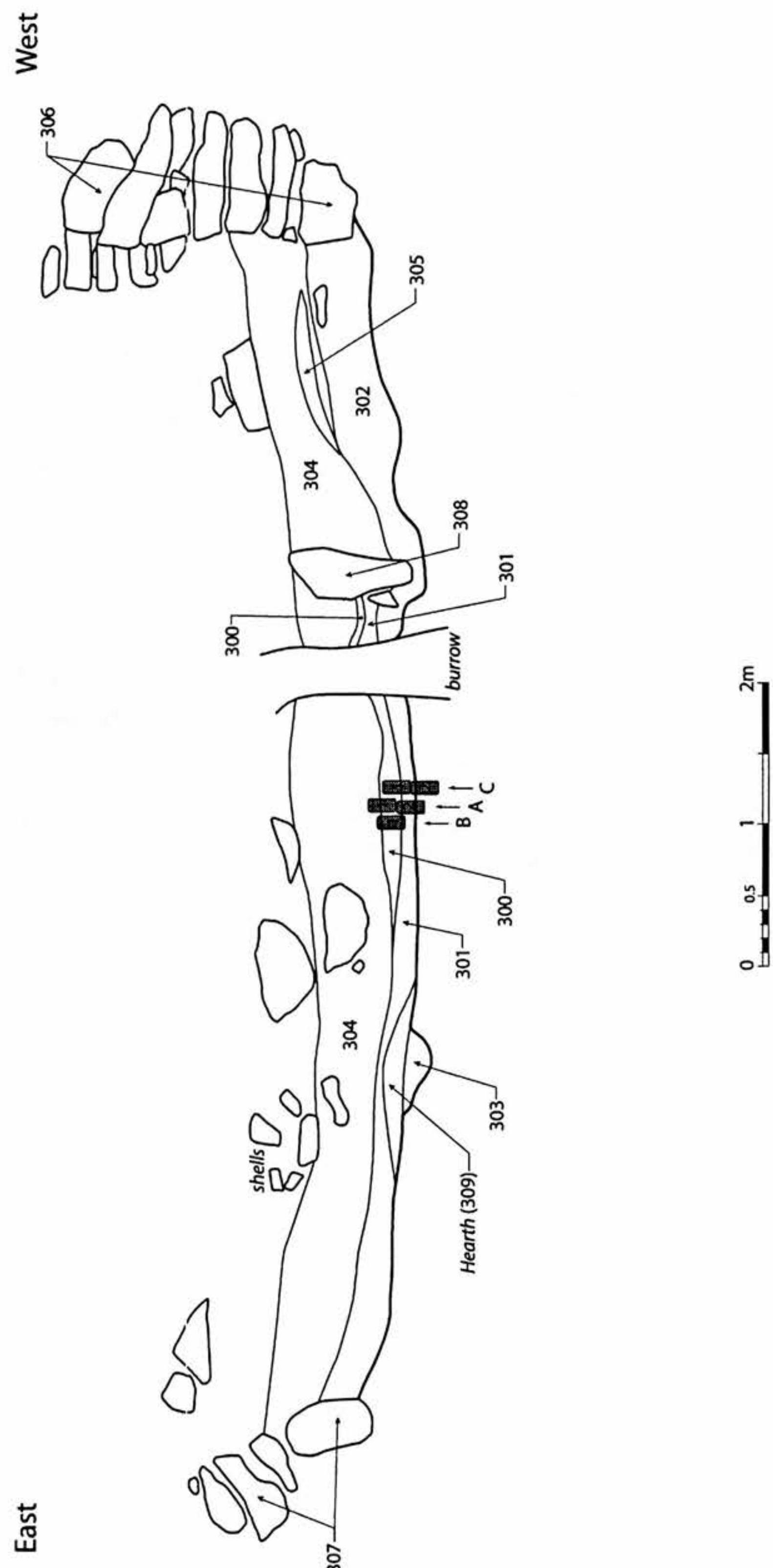


Figure 4.28: Section of eroding face 2a at Galson (Source: Neighbour & Church, 2001)

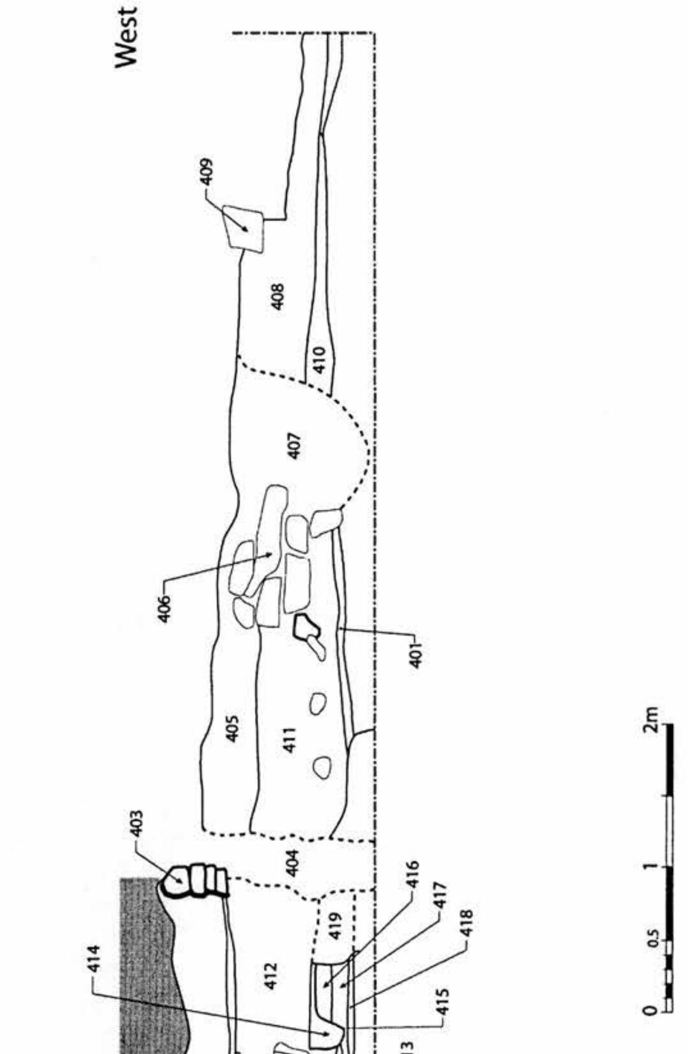


Figure 4.29: Section of eroding face 2b at Galson (Source: Neighbour & Church, 2001)

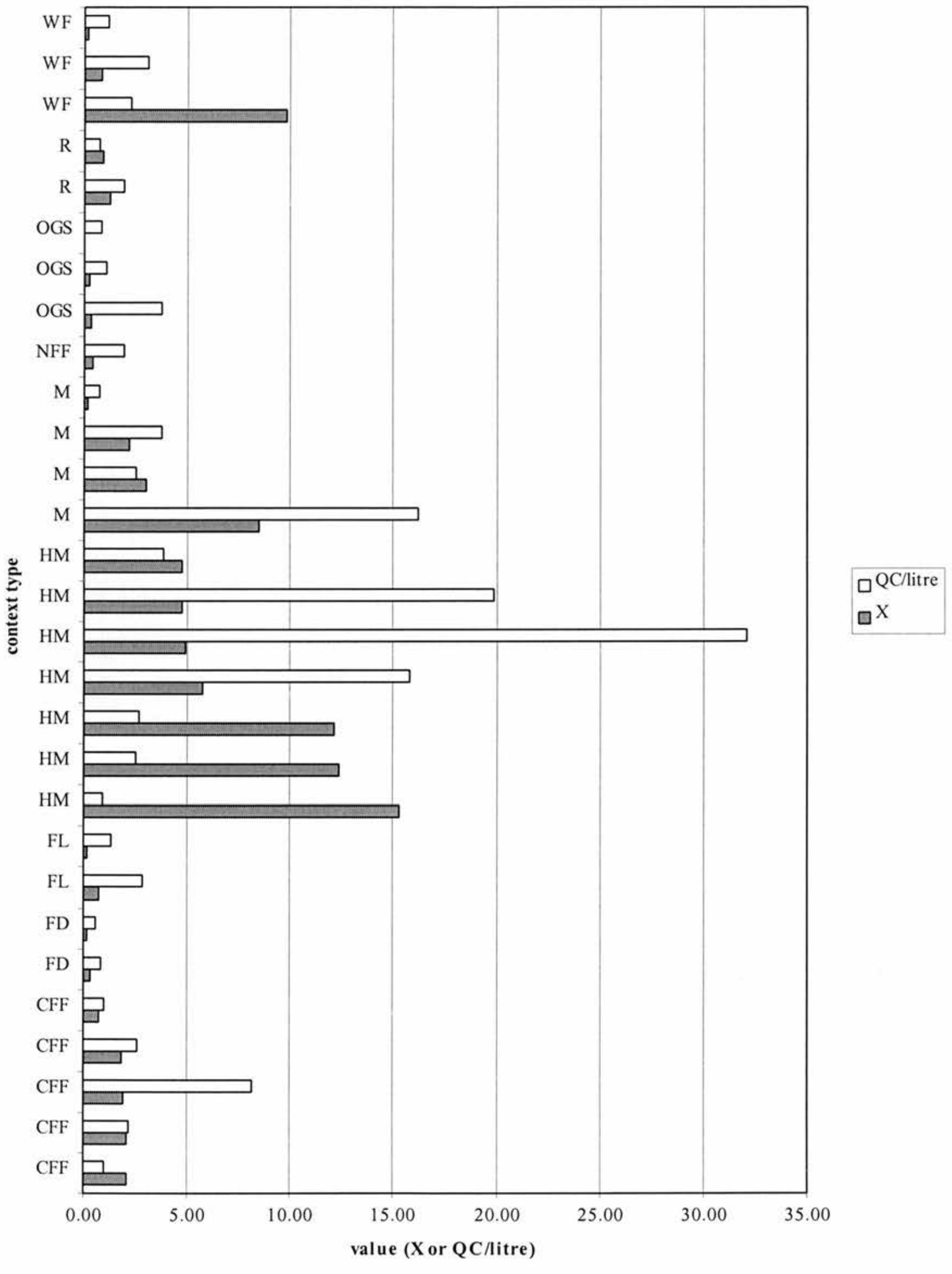


Figure 5.1: χ (units = $\mu m^3 kg^{-1}$) and QC/litre for Cellular phase at Loch na Beirgh (**LB-C**). Generic context type abbreviations are given in Table 3.7.

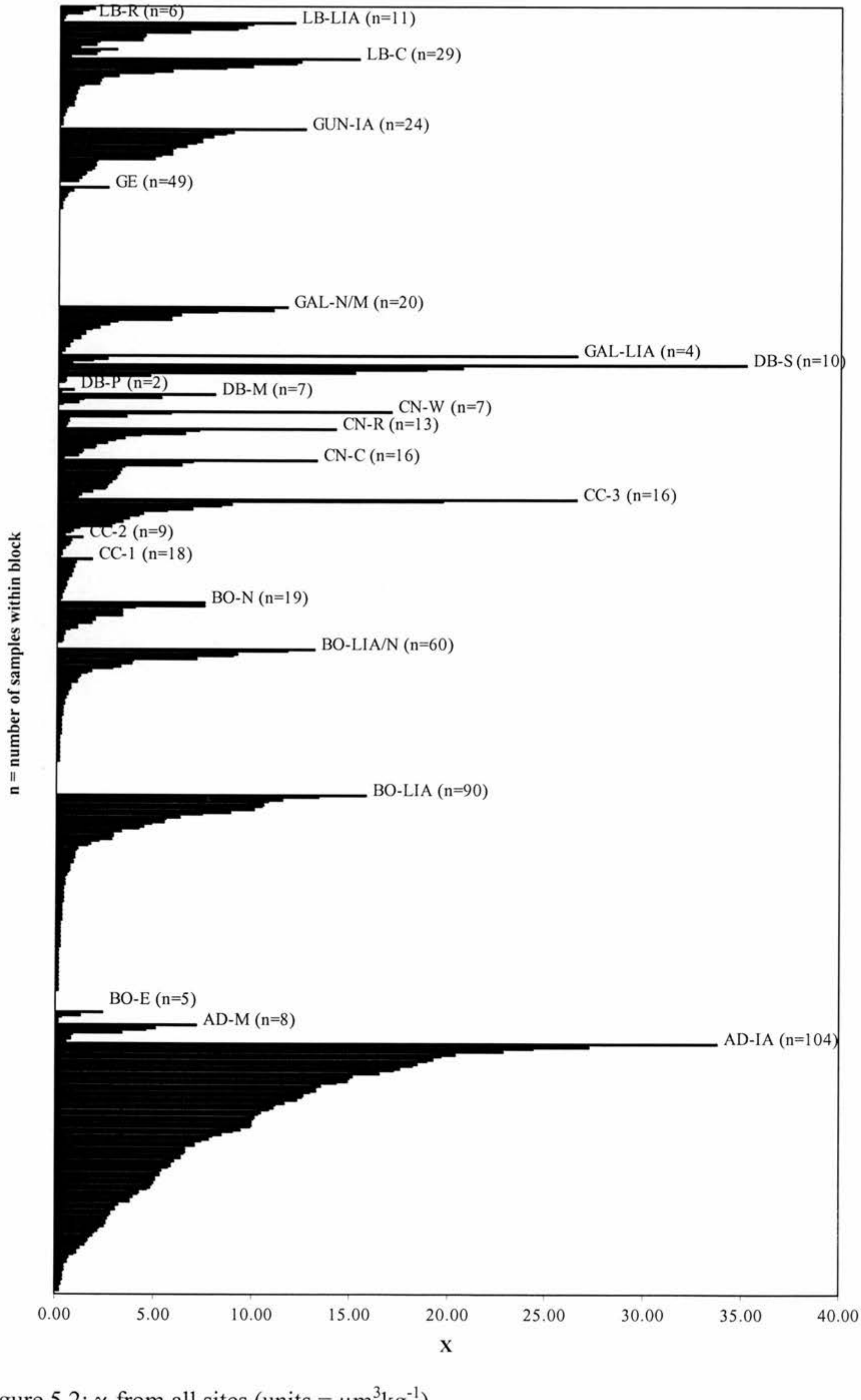


Figure 5.2: χ from all sites (units = $\mu m^3 kg^{-1}$)

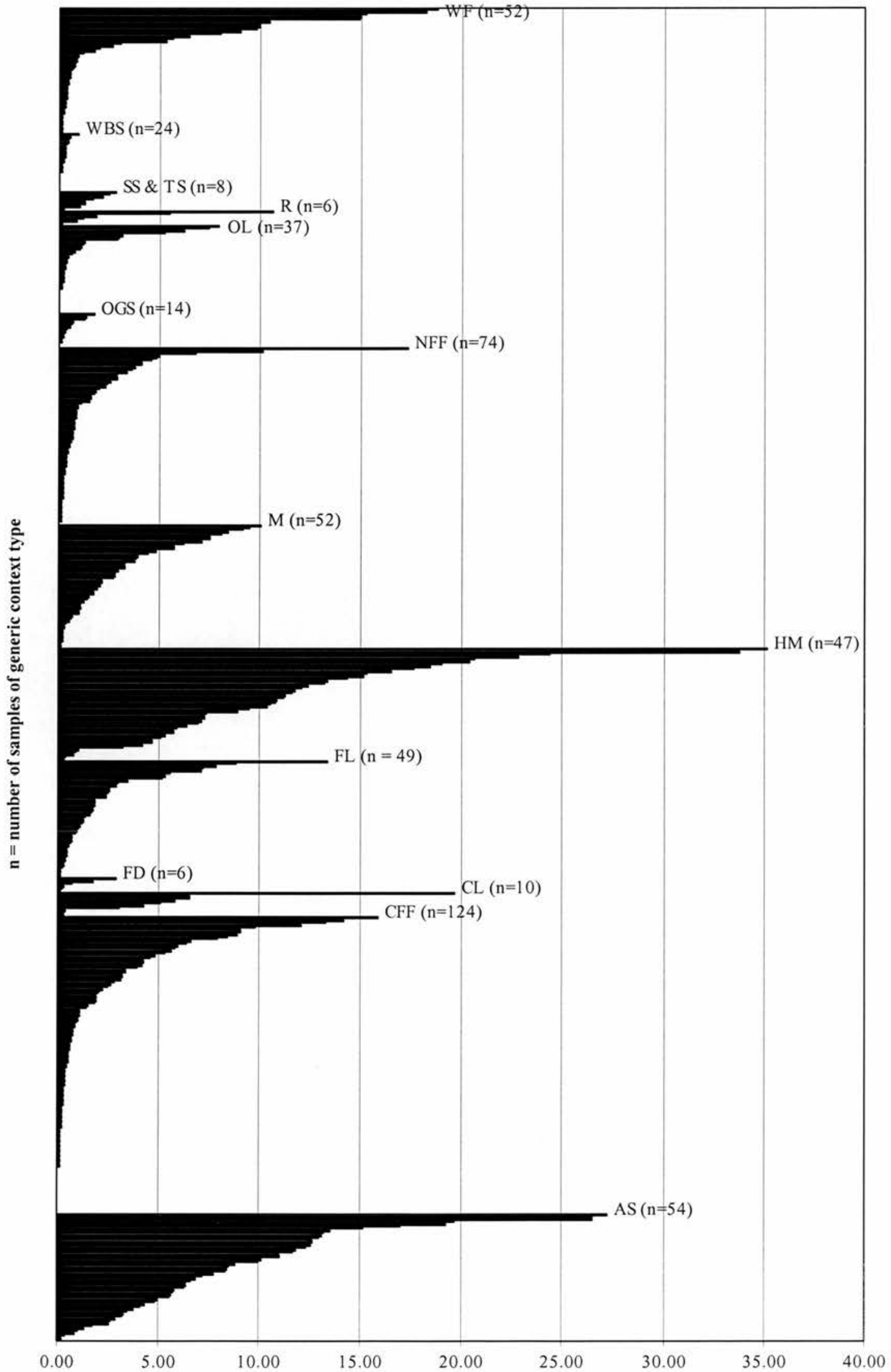


Figure 5.3: χ by main context types from all sites (except Gob Eirer; units = $\mu m^3 kg^{-1}$)

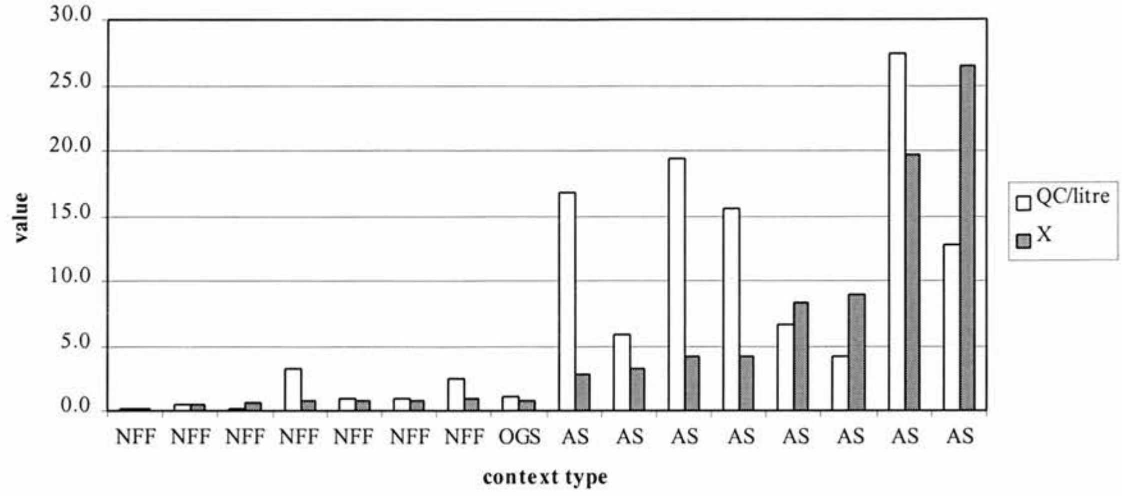


Figure 5.4: χ (units = $\mu m^3 kg^{-1}$) and QC/litre for Calanais kerb cairn

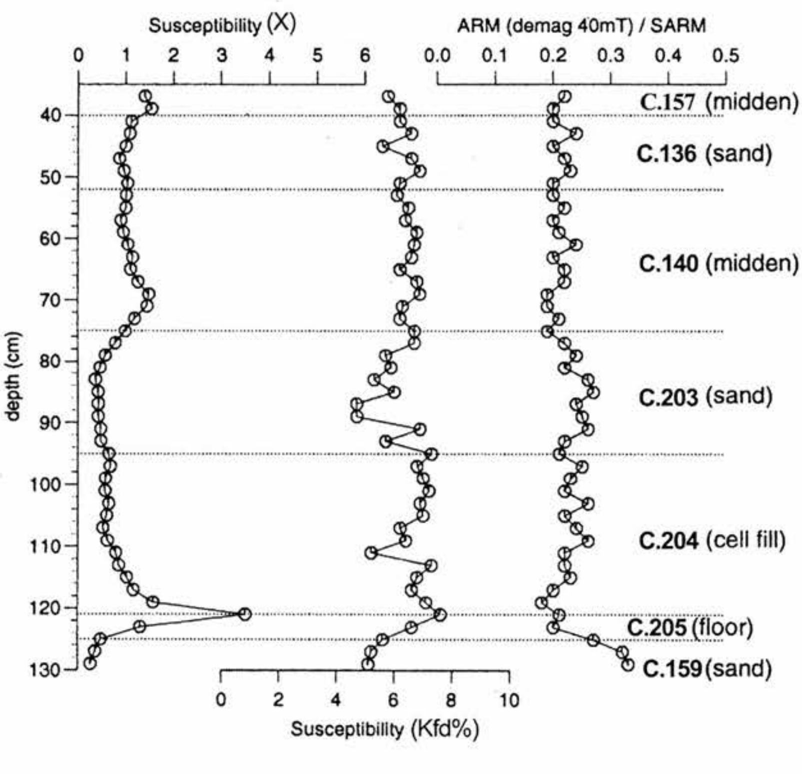


Figure 5.5a: Mineral magnetic sampling points MS1 at Galson, Structural complex B (χ units = $\mu m^3 kg^{-1}$)

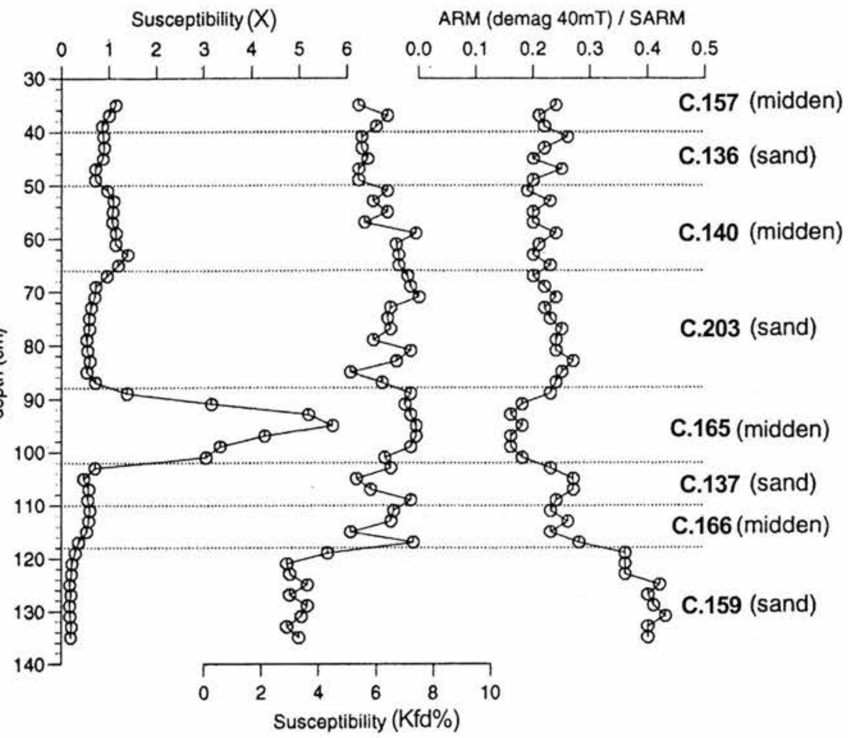


Figure 5.5b: Mineral magnetic sampling points MS1 at Galson, Structural complex B (χ units = $\mu m^3 kg^{-1}$)

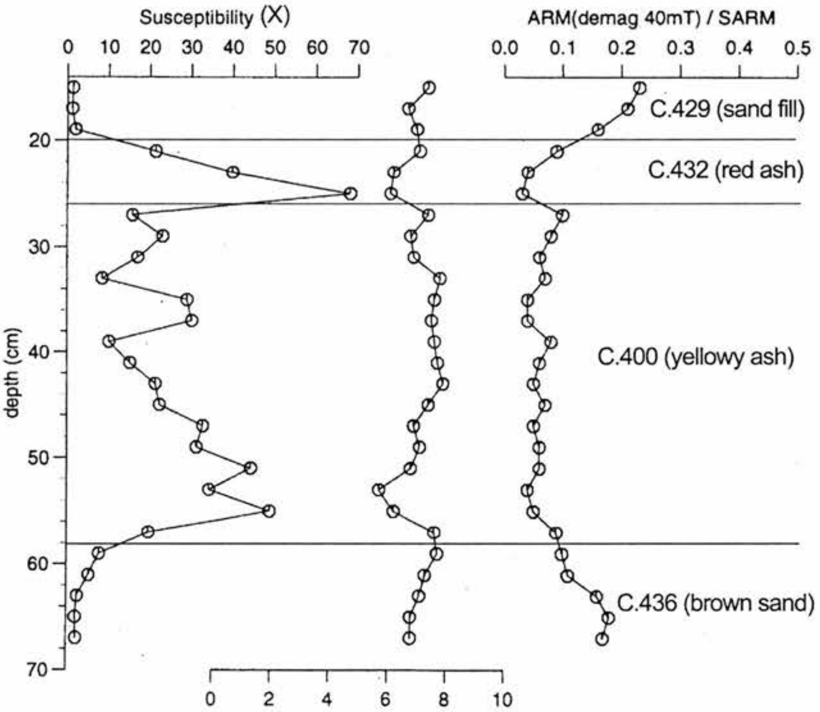


Figure 5.6: Mineral magnetic sampling points MS3 at Galson, Structural complex C (χ units = $\mu m^3 kg^{-1}$)

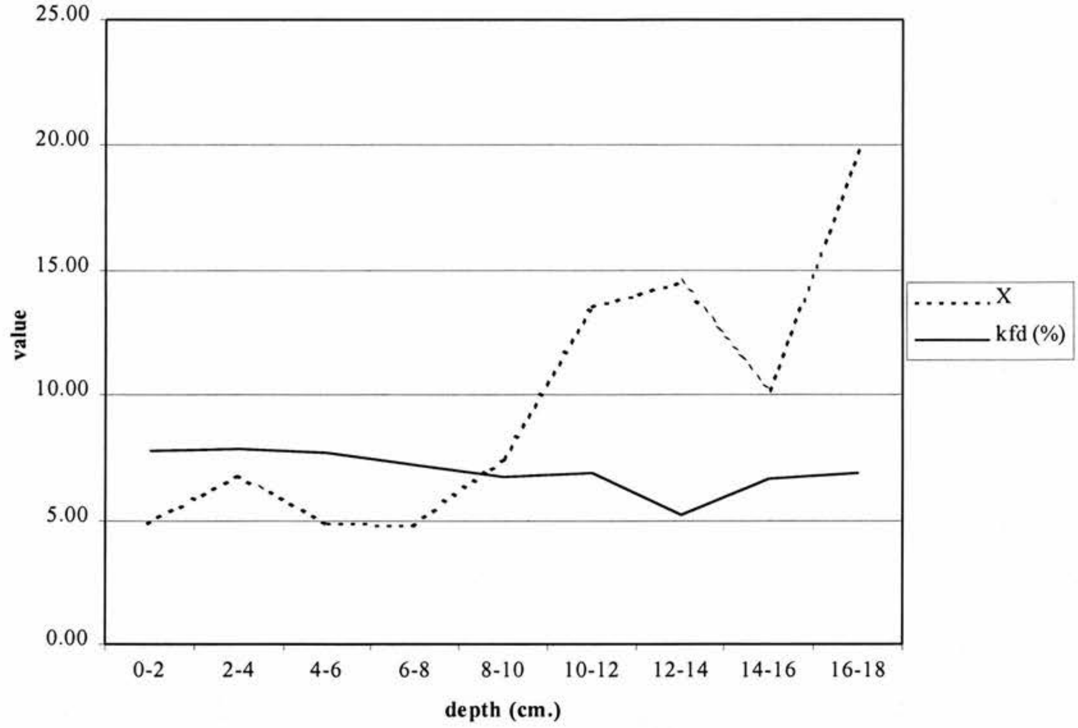


Figure 5.7: χ (units = $\mu m^3 kg^{-1}$) values through hearth at Guinnerso (Source: Mitchell, 1998)

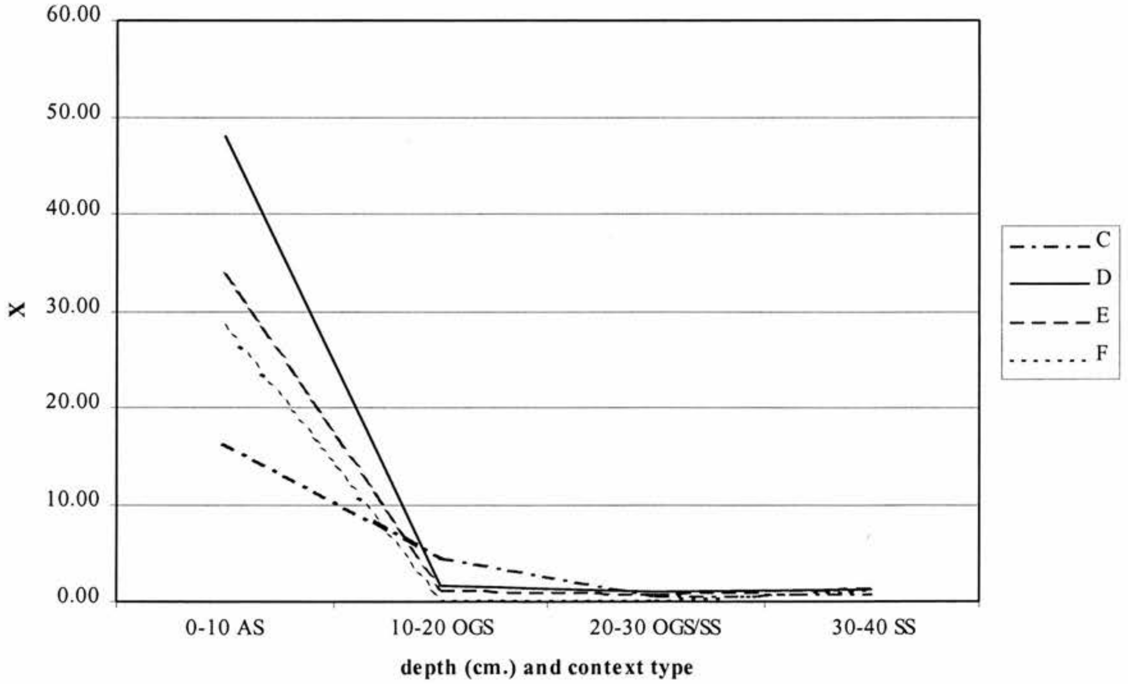


Figure 5.8: χ (units = $\mu m^3 kg^{-1}$) values through ash spreads at Calanais kerb cairn

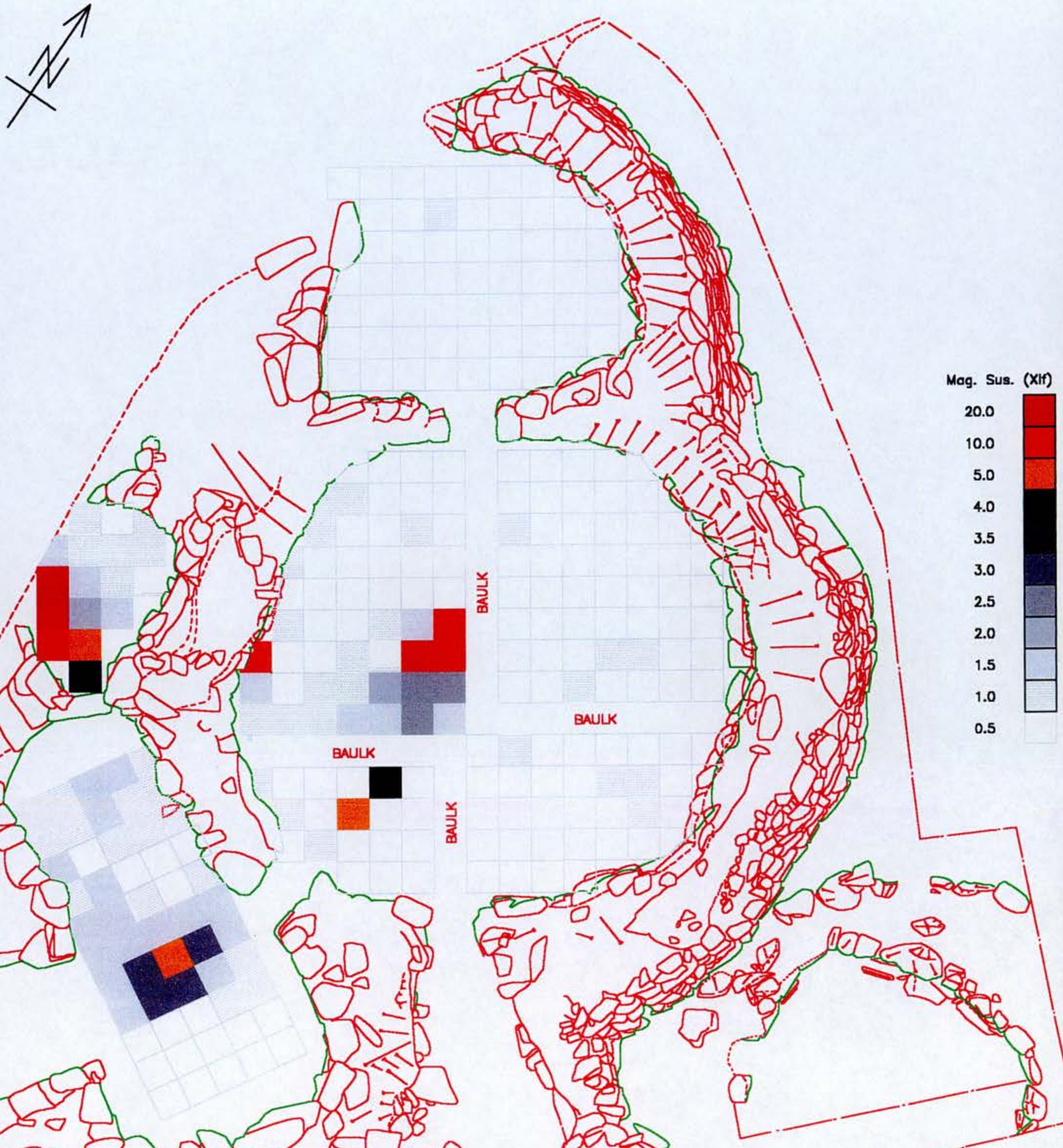


Figure 5.9a: X from floor grid at Bostadh (source: Young 2002)

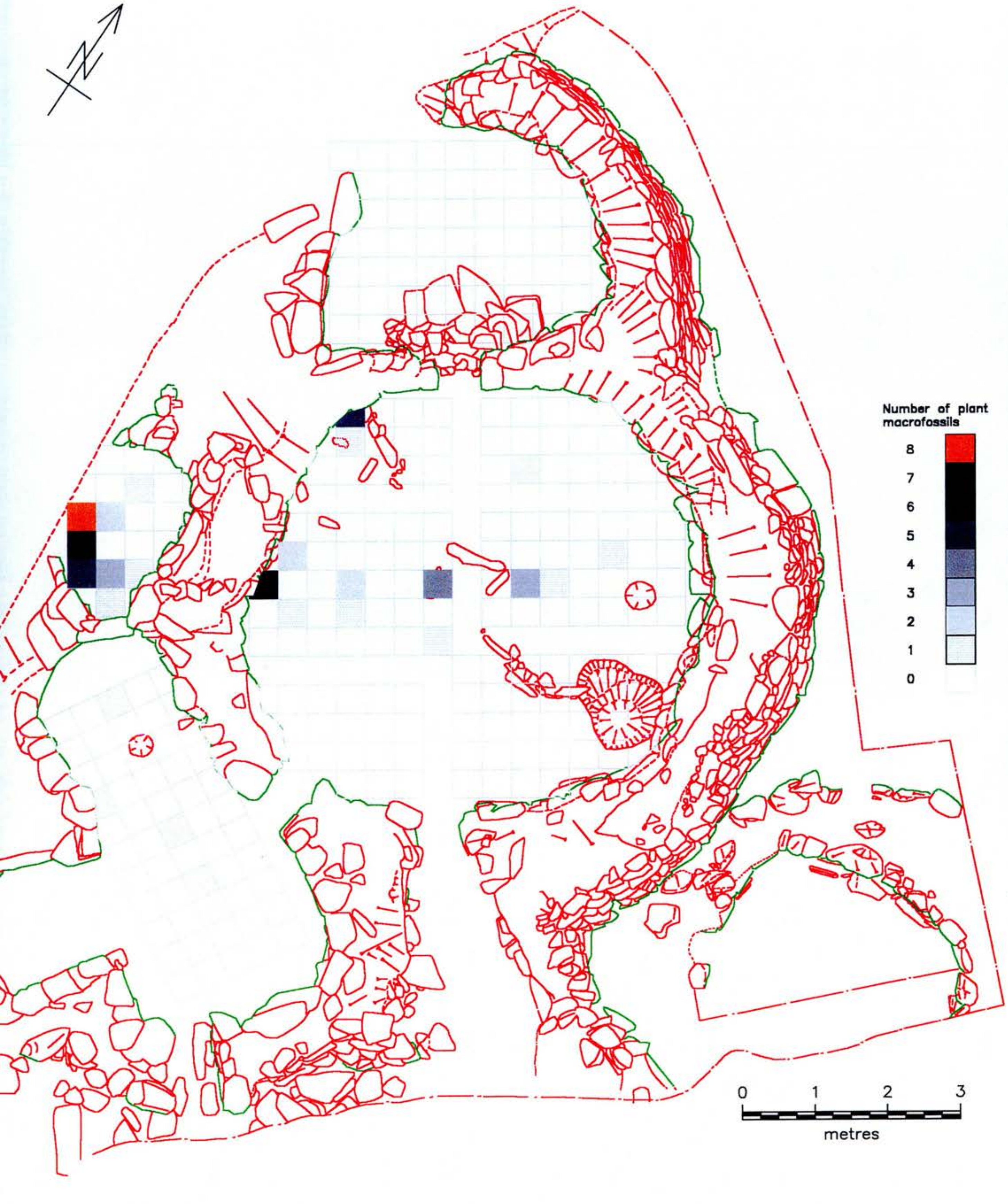


Figure 5.9b: Total quantifiable components from floor grid at Bostadh (source: Young 2002)

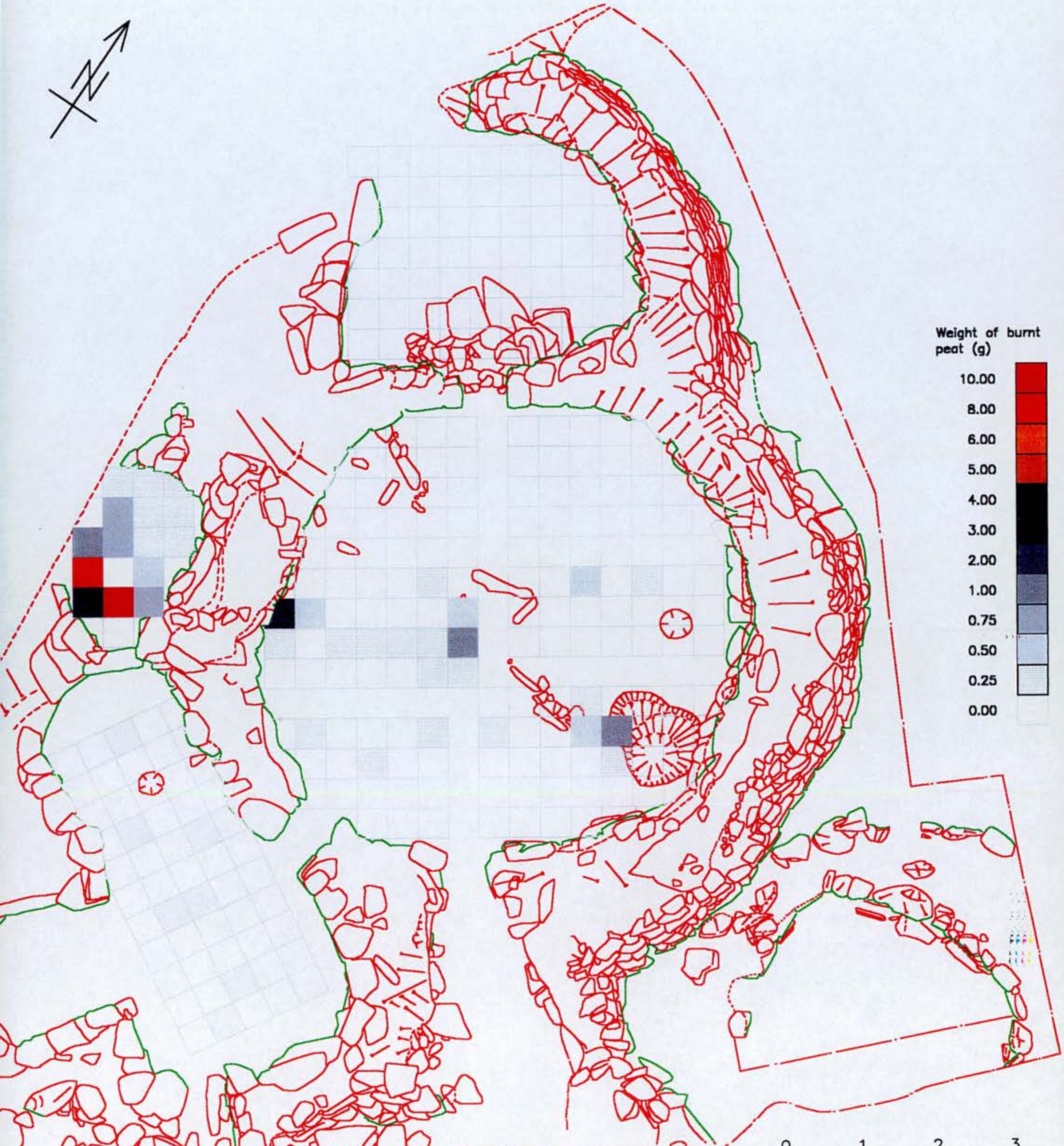


Figure 5.9c: Weight of burnt peat from floor grid at Bostadh (source: Young 2002)

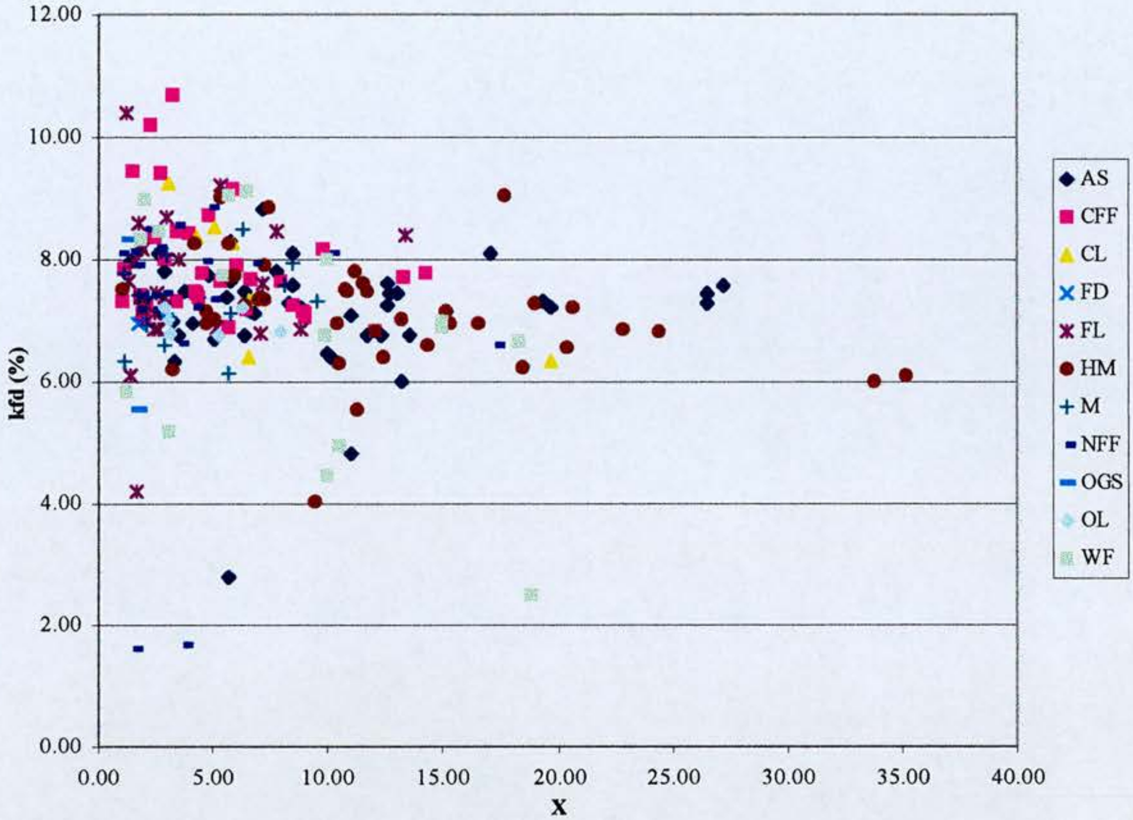


Figure 5.10: χ (units = $\mu m^3 kg^{-1}$) by κ_{fd} for all samples with κ_{lf} values >100. Generic context type abbreviations are given in Table 3.7.

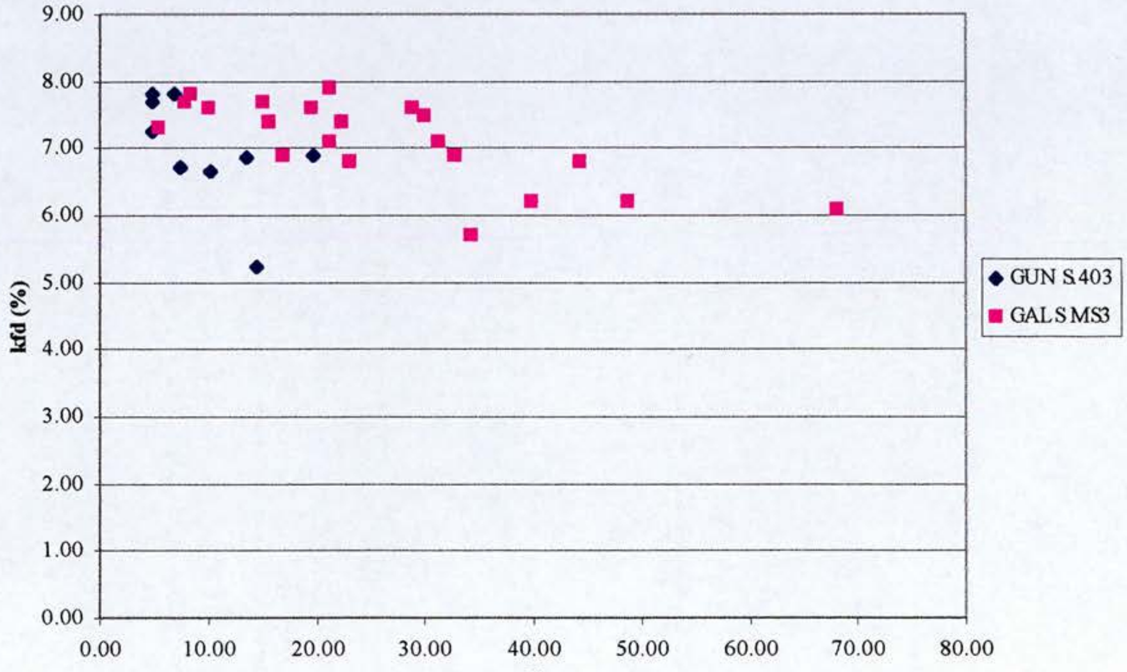


Figure 5.11: χ (units = $\mu m^3 kg^{-1}$) by κ_{fd} for Galson MS3 and Guinnerso hearth samples with κ_{lf} values >100

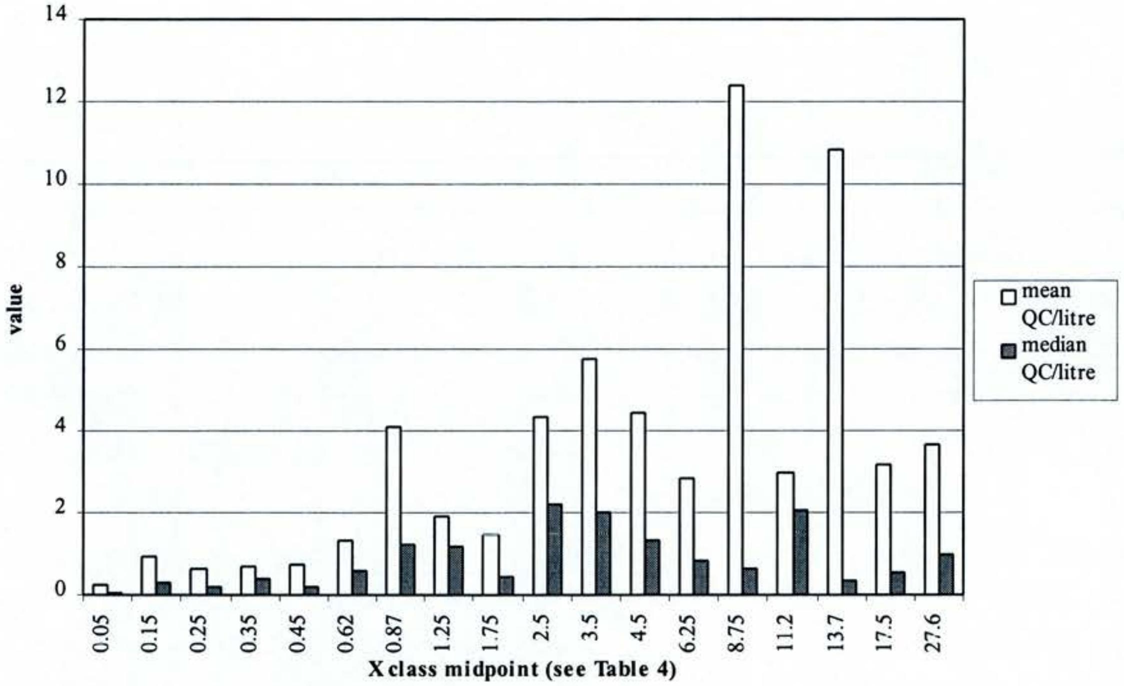


Figure 5.12: χ (units = $\mu m^3 kg^{-1}$) class midpoints and QC/litre for all sites (based on data from Table 5.3)

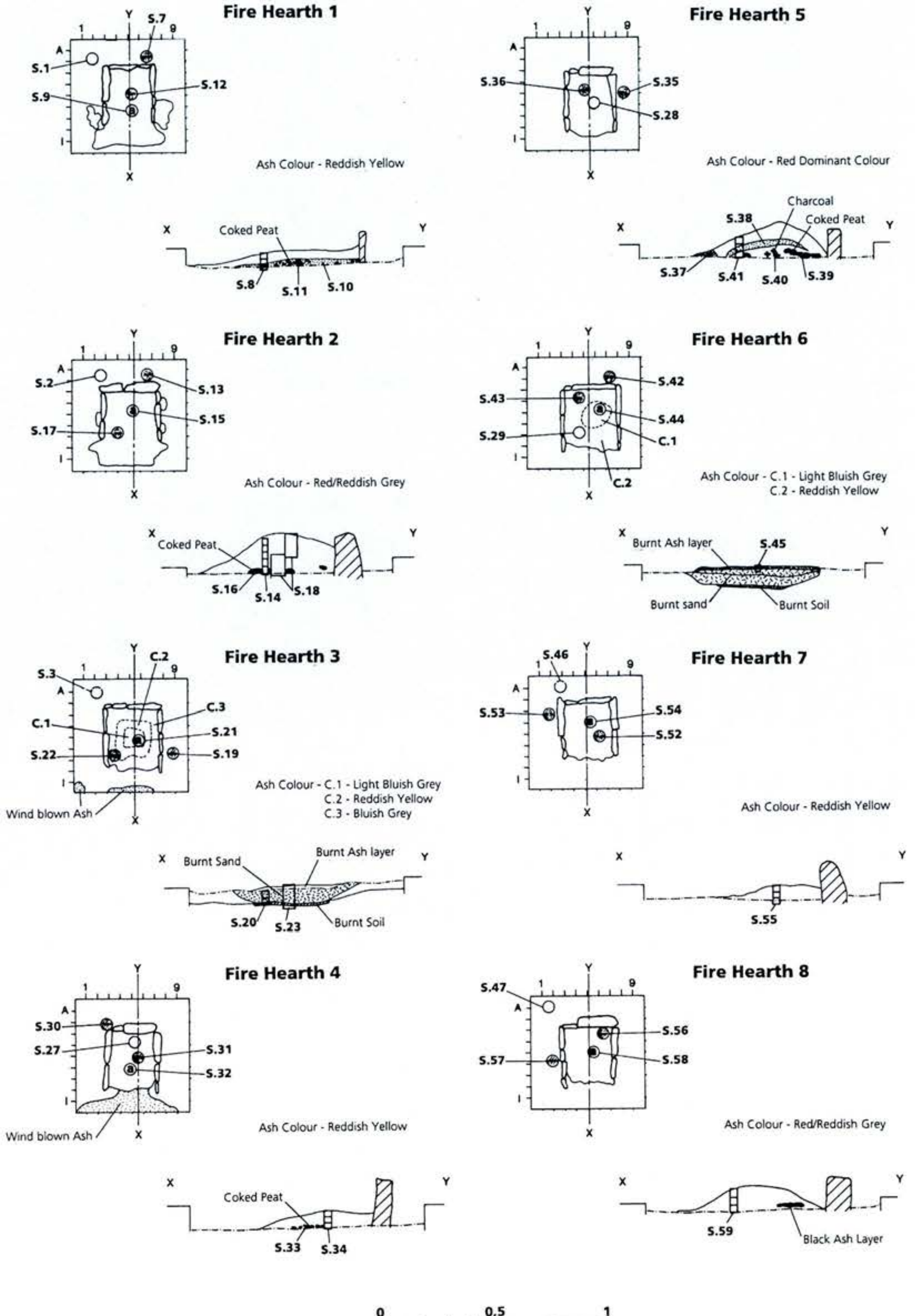


Figure 5.13a: Experimental fire hearth plans and sections

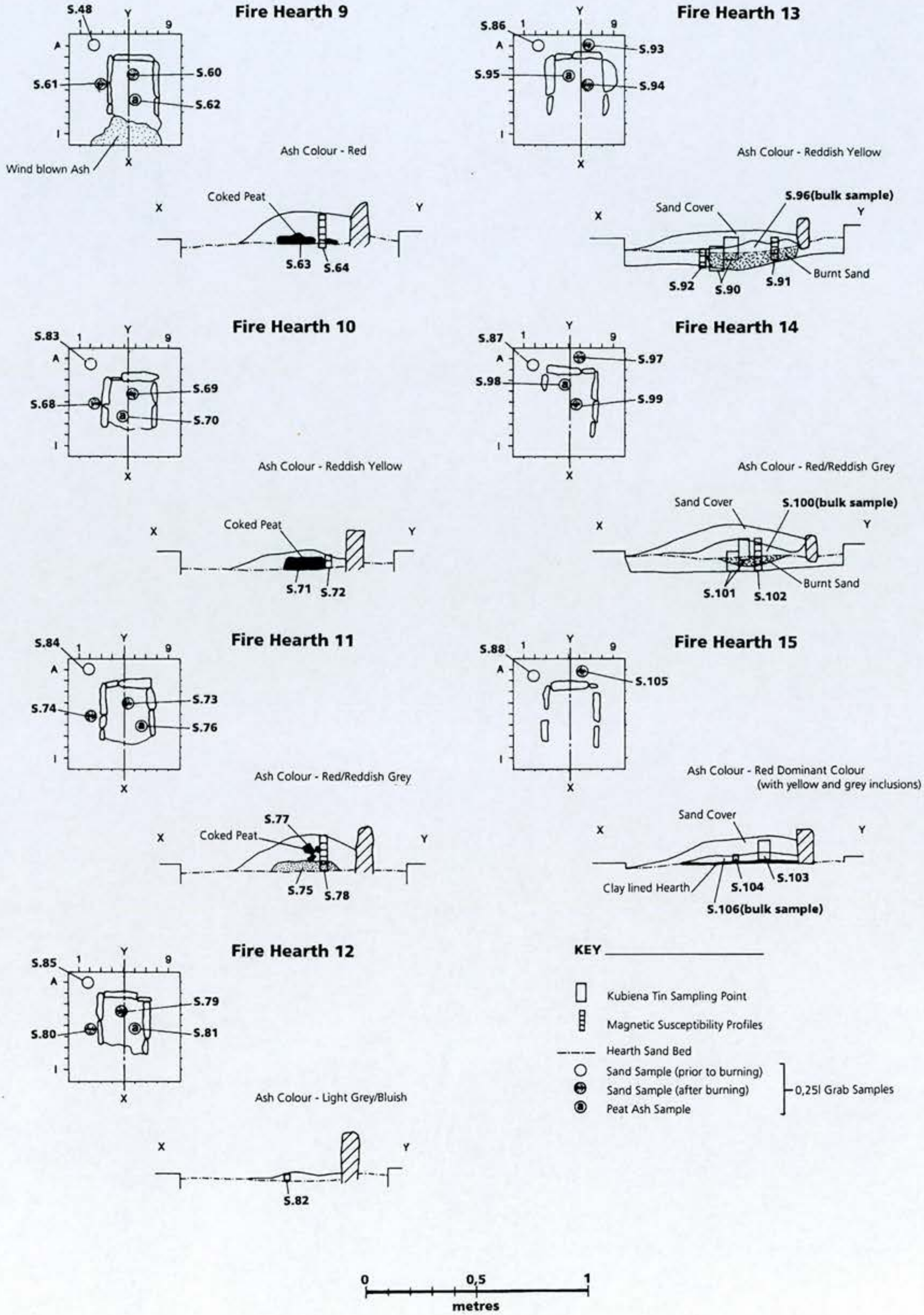


Figure 5.13b: Experimental fire hearth plans and sections

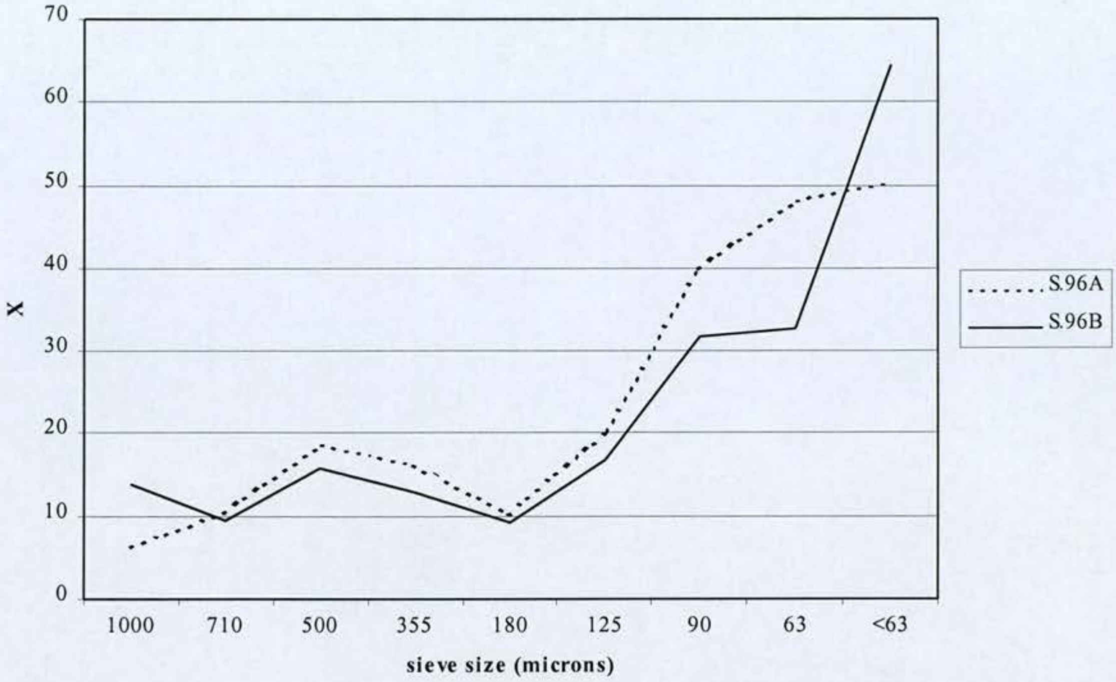


Figure 5.14: χ (units = $\mu m^3 kg^{-1}$) for different sieve sizes of experimental ash S.96

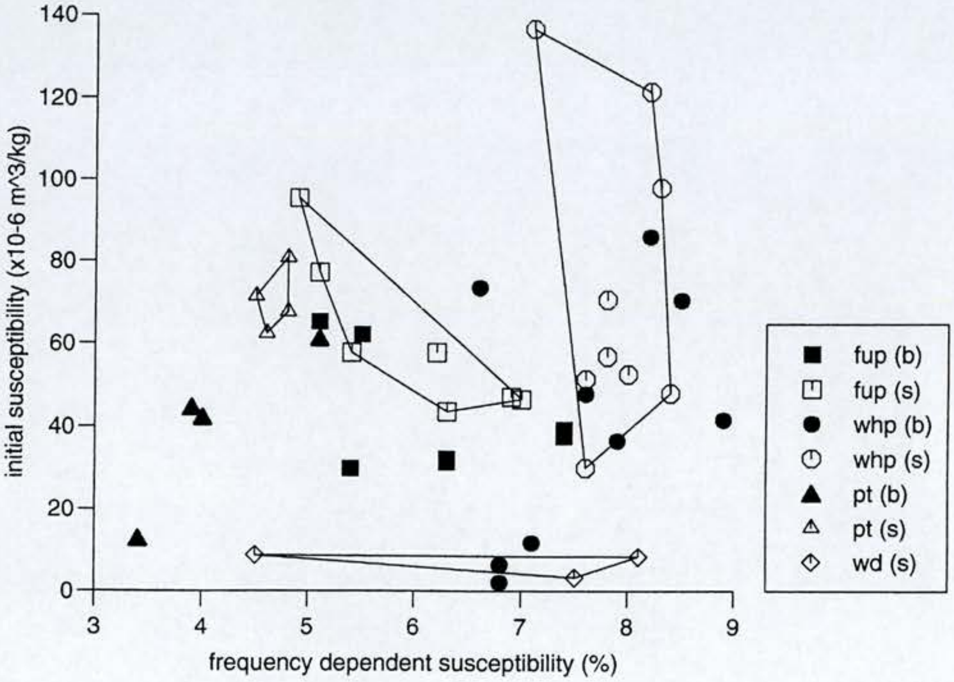


Figure 5.15: χ by κ_{fd} for the bulk (b) and sieved (s) ash samples. Fup = fibrous upper peat, whp is well humified peat, pt is peaty turf and wd is wood (Source: Peters *et al.*, 2001)

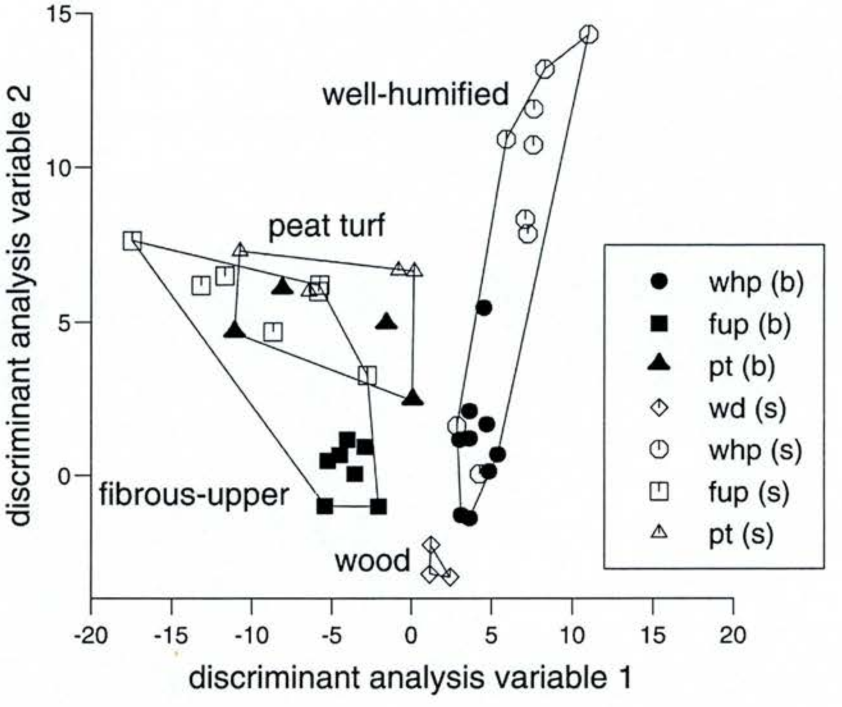


Figure 5.16: Stepwise discriminant analysis of the room temperature magnetic data (Source: Peters *et al.*, 2001)

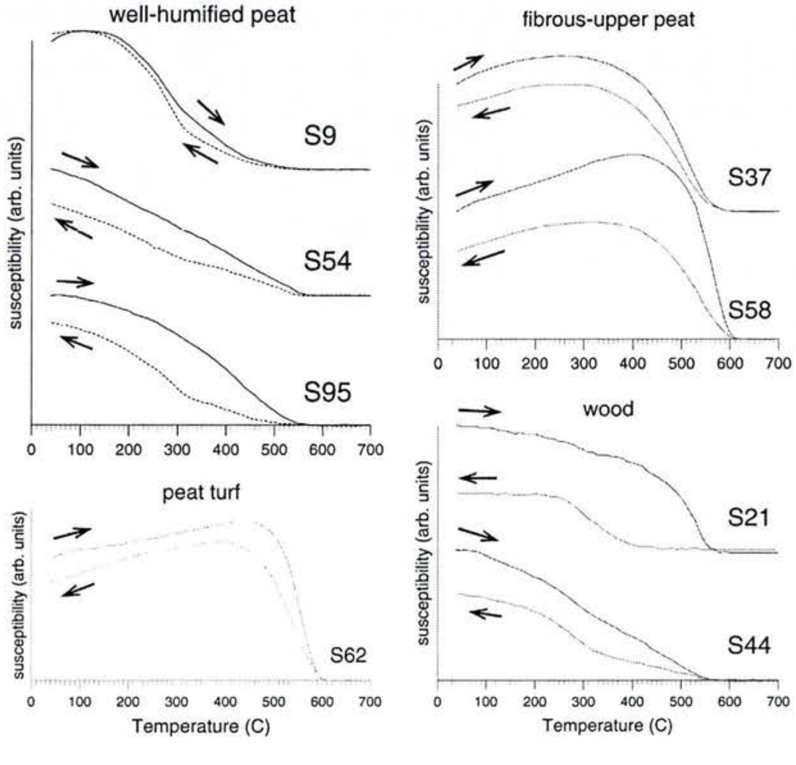


Figure 5.17: Variation of susceptibility with temperature for a selection of eight experimental ash samples (Source: Peters *et al.*, 2001)

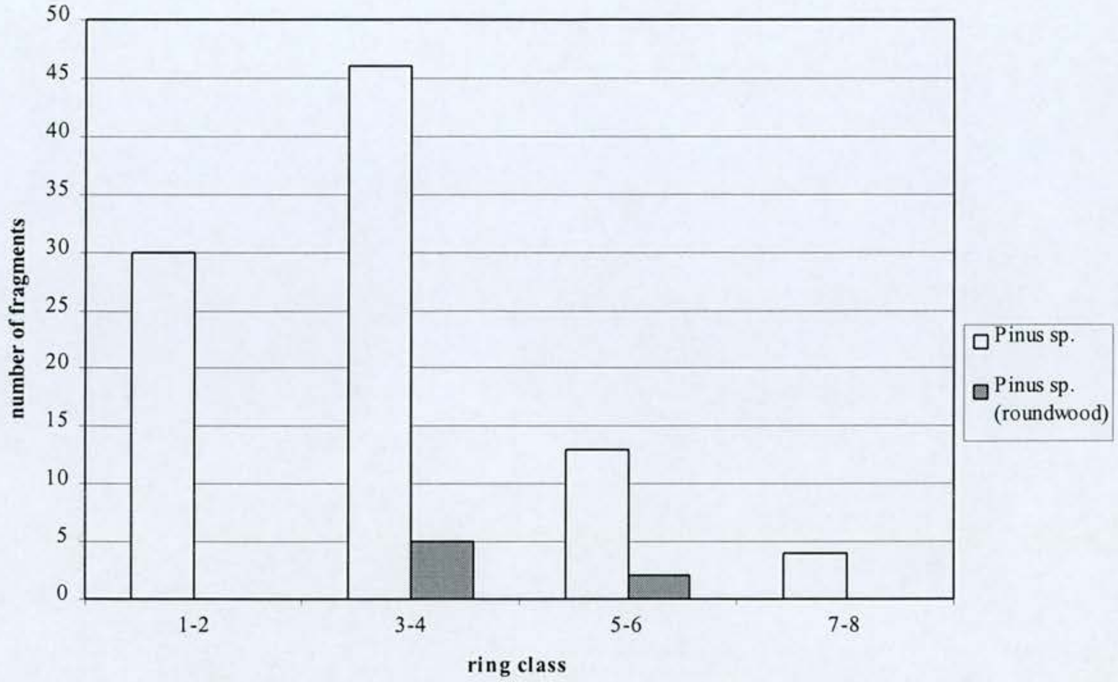


Figure 5.18: Ring profile from pine charcoal in experimental hearths

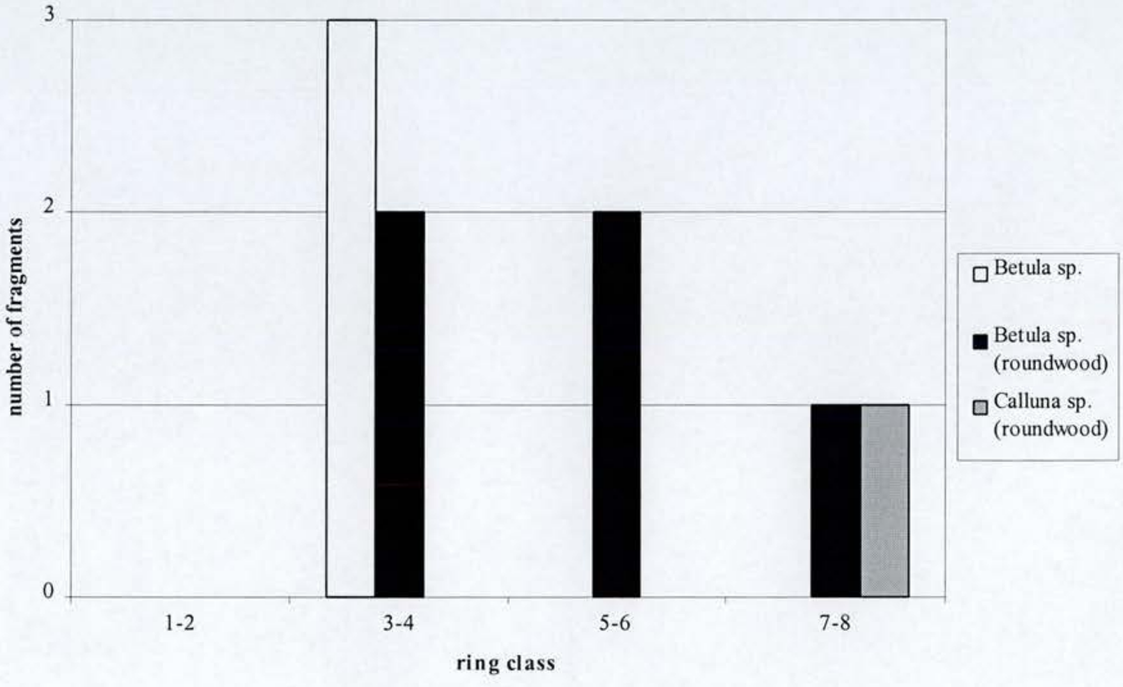


Figure 5.19: Ring profile of birch and Ling heather charcoal in experimental hearths

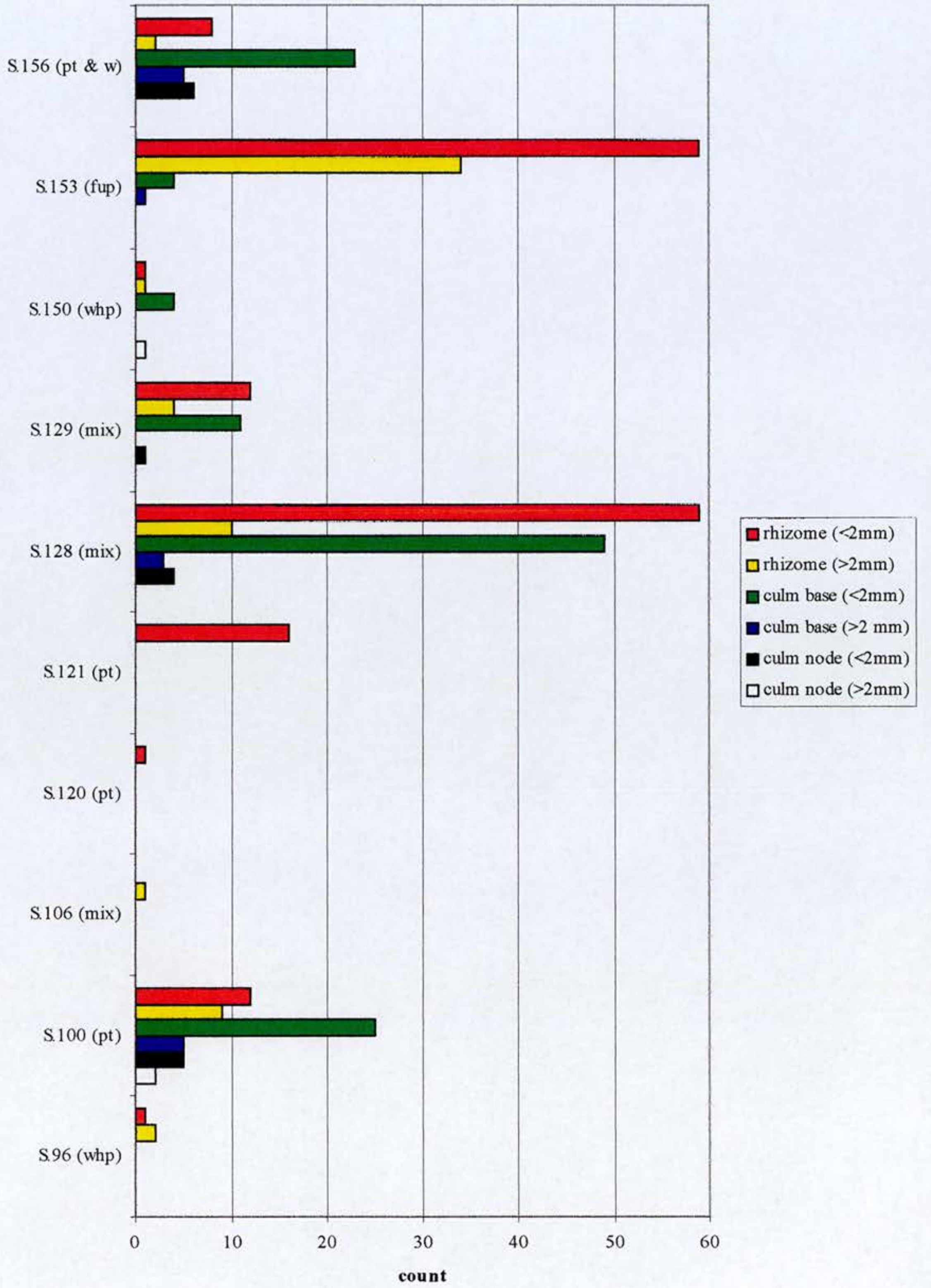


Figure 5.20: Culm node/base and rhizome size distribution from experimental hearths. Fup = fibrous upper peat, whp = well-humified peat, pt = peaty turf, wd = wood and mix = mixture of fuel types.

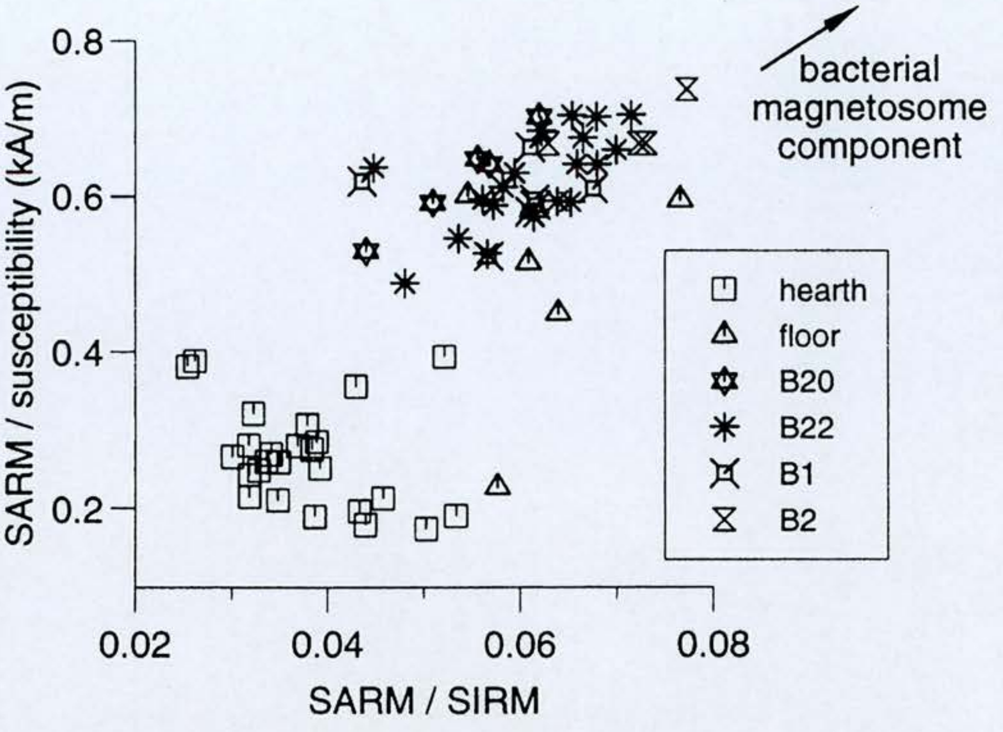


Figure 5.21: Bacterial magnetosome component in floor levels and middens at Galson (Source: Peters *et al.*, 2000)

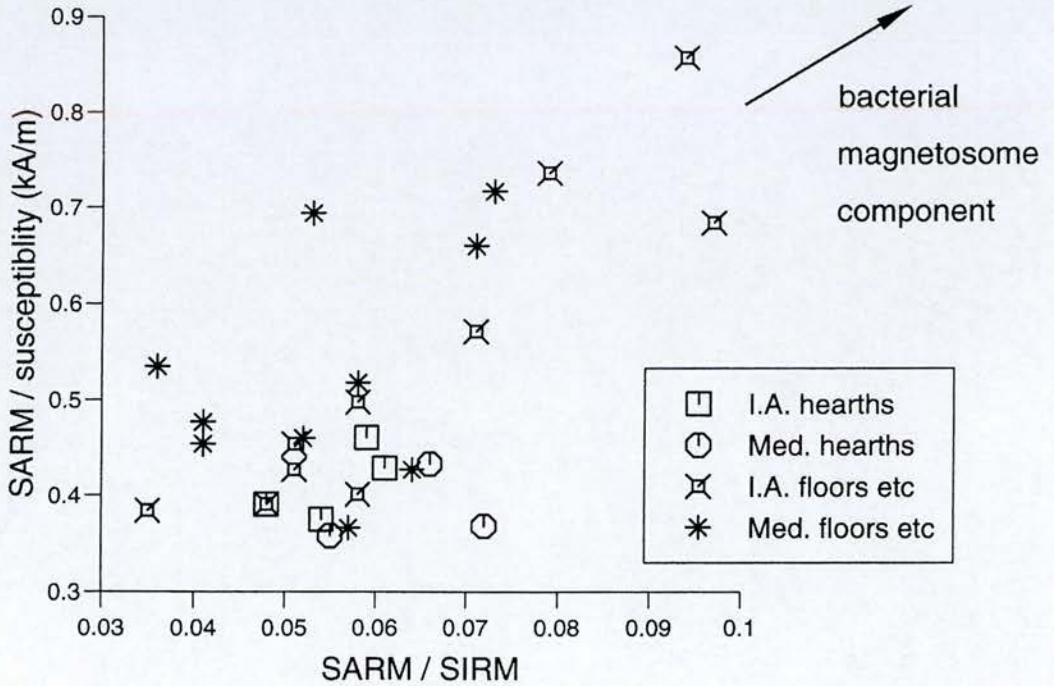


Figure 5.22: Bacterial magnetosome component in floor levels at Guinnerso (Source: Peters *et al.*, 2001)

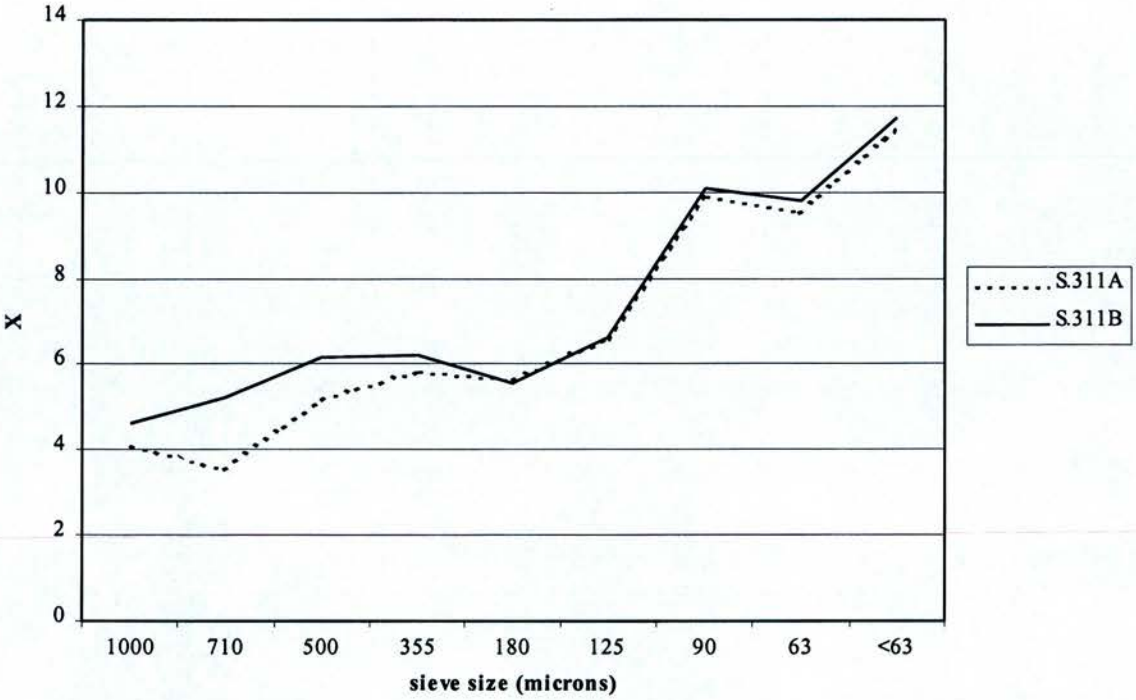


Figure 5.23: χ (units = μm^3kg^{-1}) for different sieve sizes of ash from Guinnerso hearth material

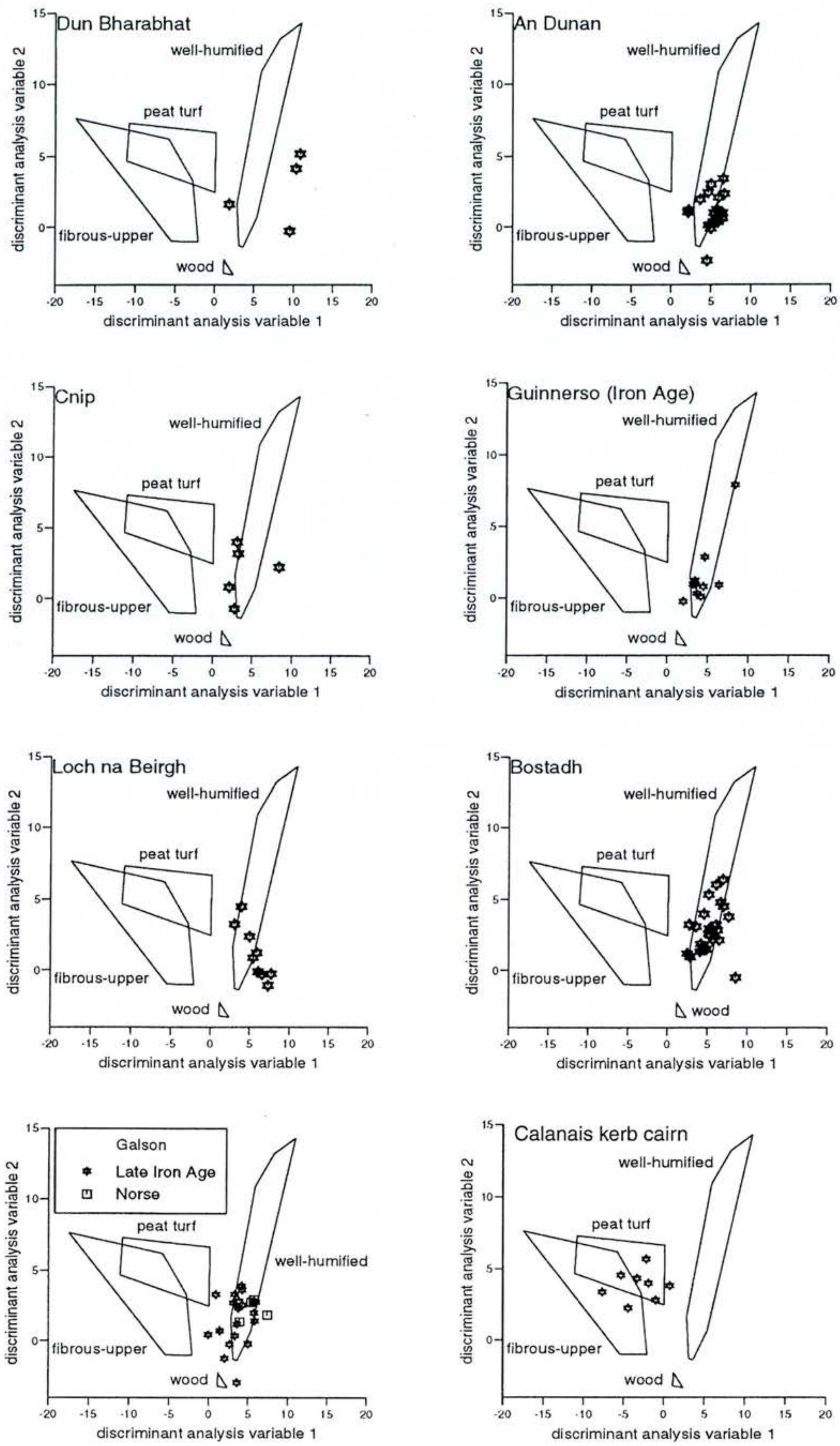


Figure 5.24: Fuel sourcing of archaeological sites: discriminant analysis biplots

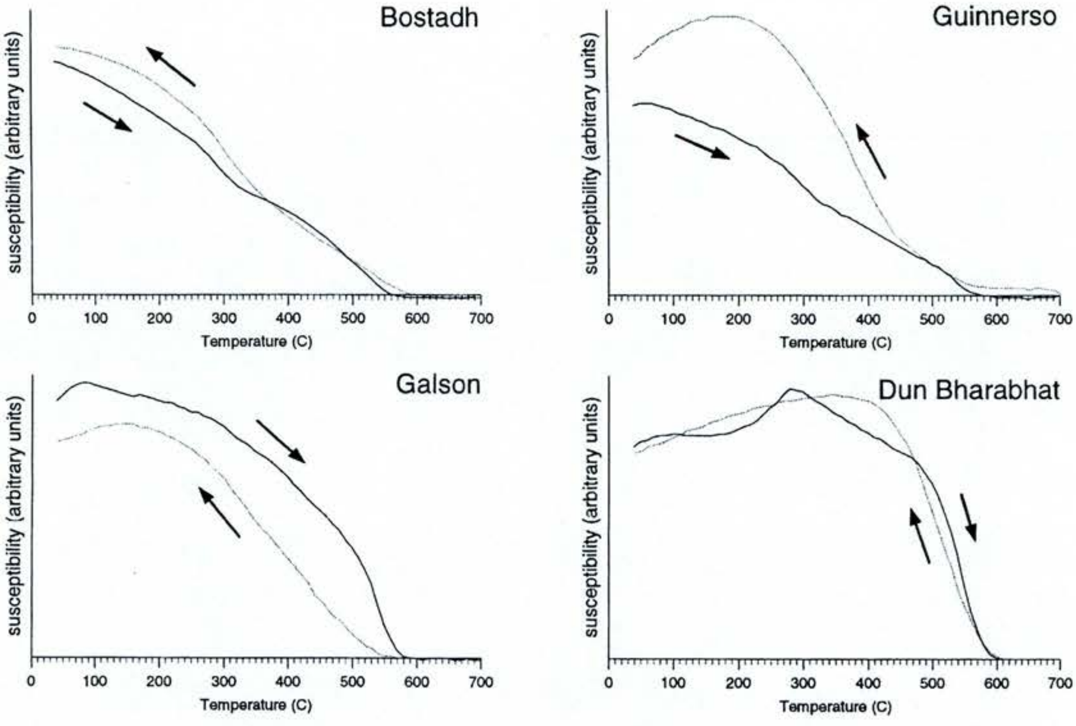


Figure 5.25: Fuel sourcing of archaeological sites: selected high temperature susceptibilities

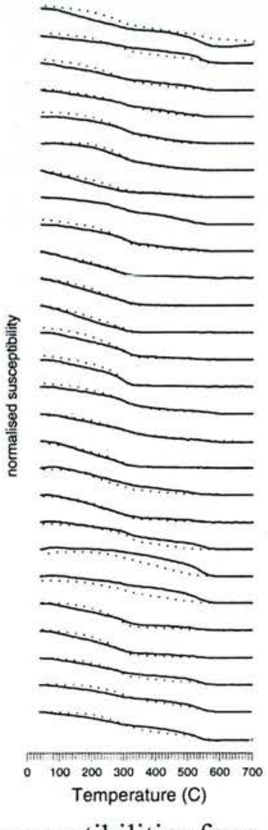


Figure 5.26: High temperature susceptibilities from MS3 profile at Galson (Source: Peters *et al.*, 2000)

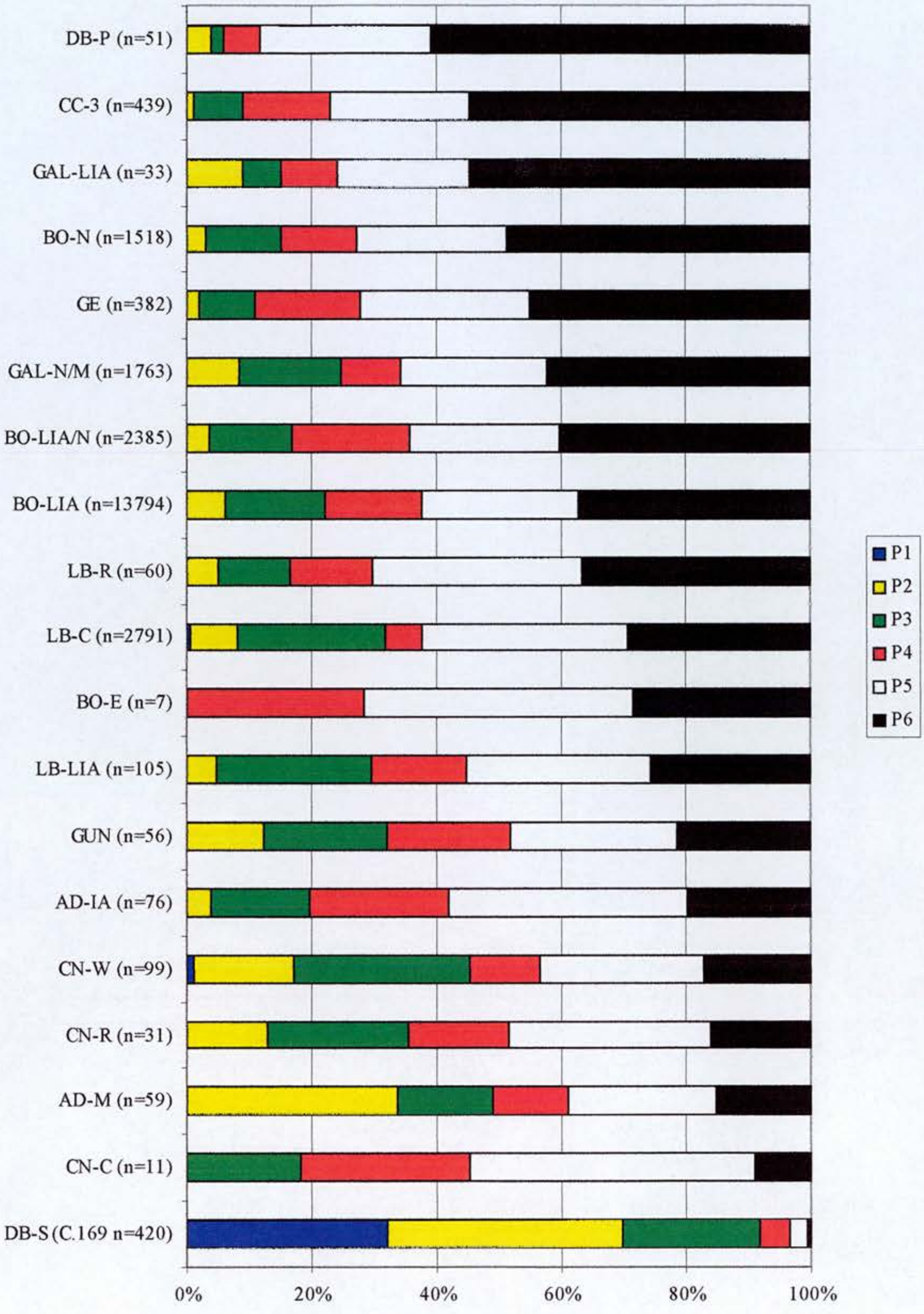


Figure 5.27: Cereal grain preservation from archaeological blocks. Preservation codes follow Hubbard & al Azm (1990).

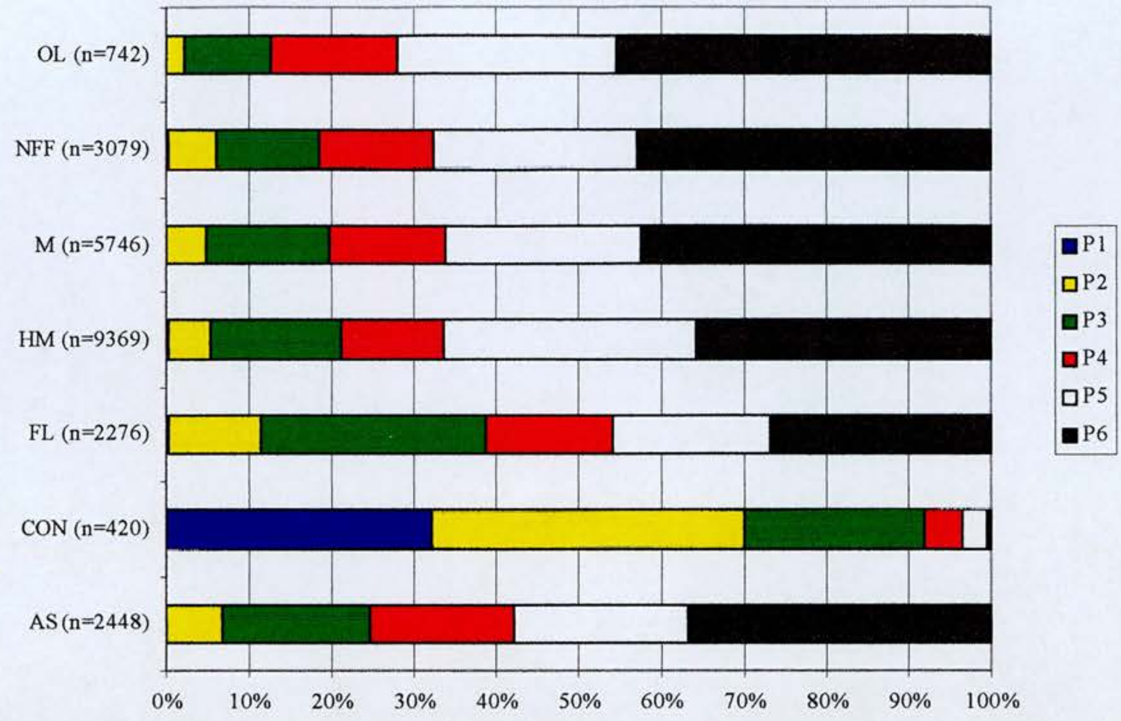


Figure 5.28: Cereal grain preservation by generic context type. Preservation codes follow Hubbard & al Azm (1990) and generic context type abbreviations are given in Table 3.7.

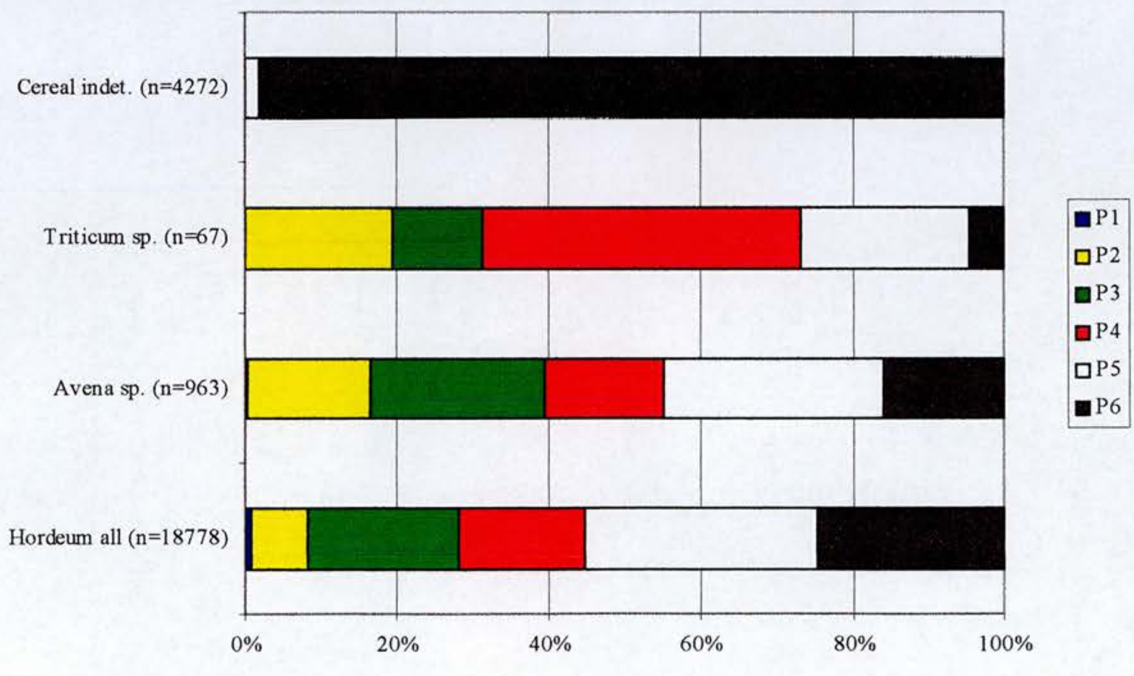


Figure 5.29: Cereal grain preservation by genera. Preservation codes follow Hubbard & al Azm (1990).

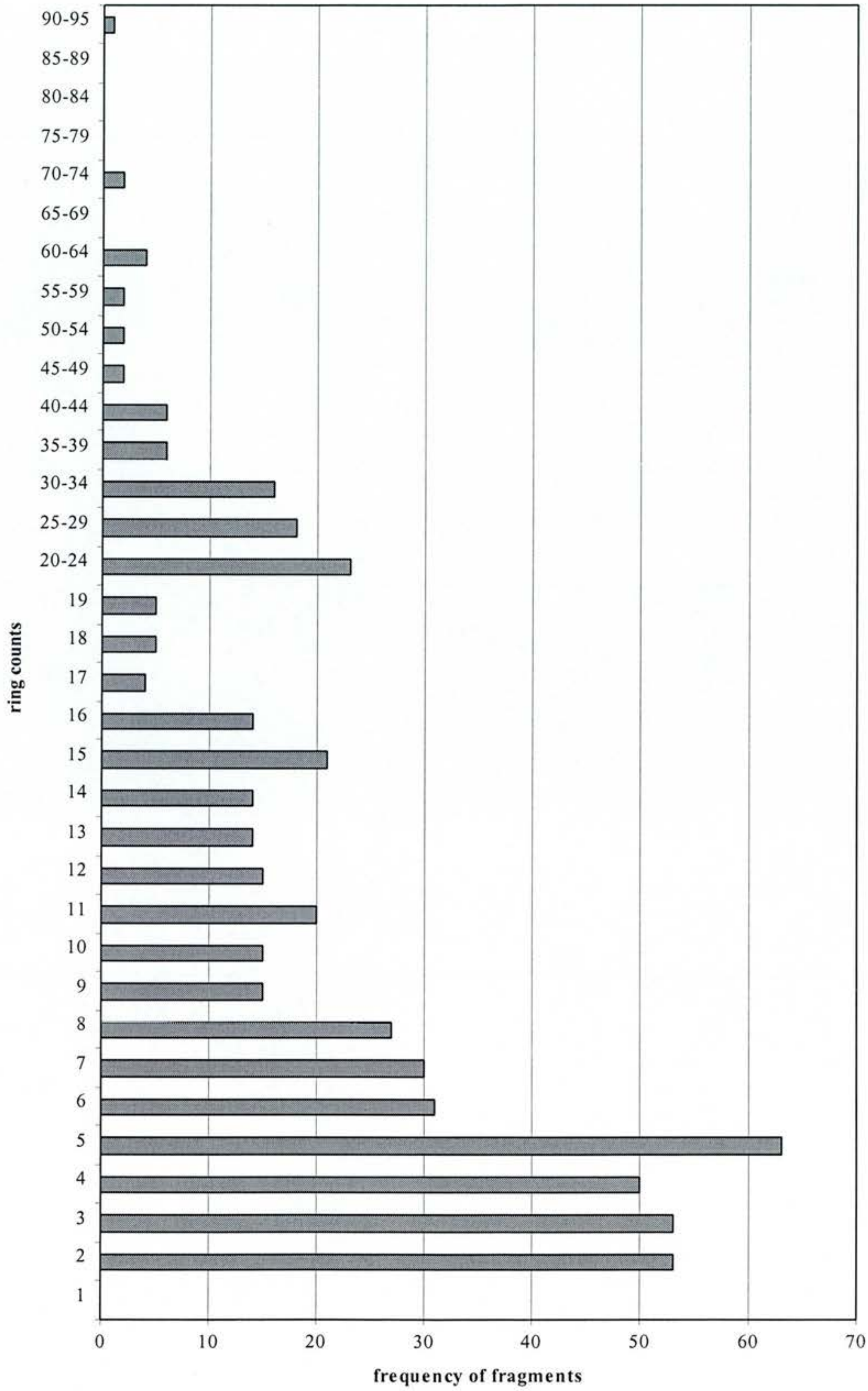


Figure 6.1: Ring counts of pine charcoal fragments from conflagration in secondary structure at Dun Bharabhat (**DB-S**)

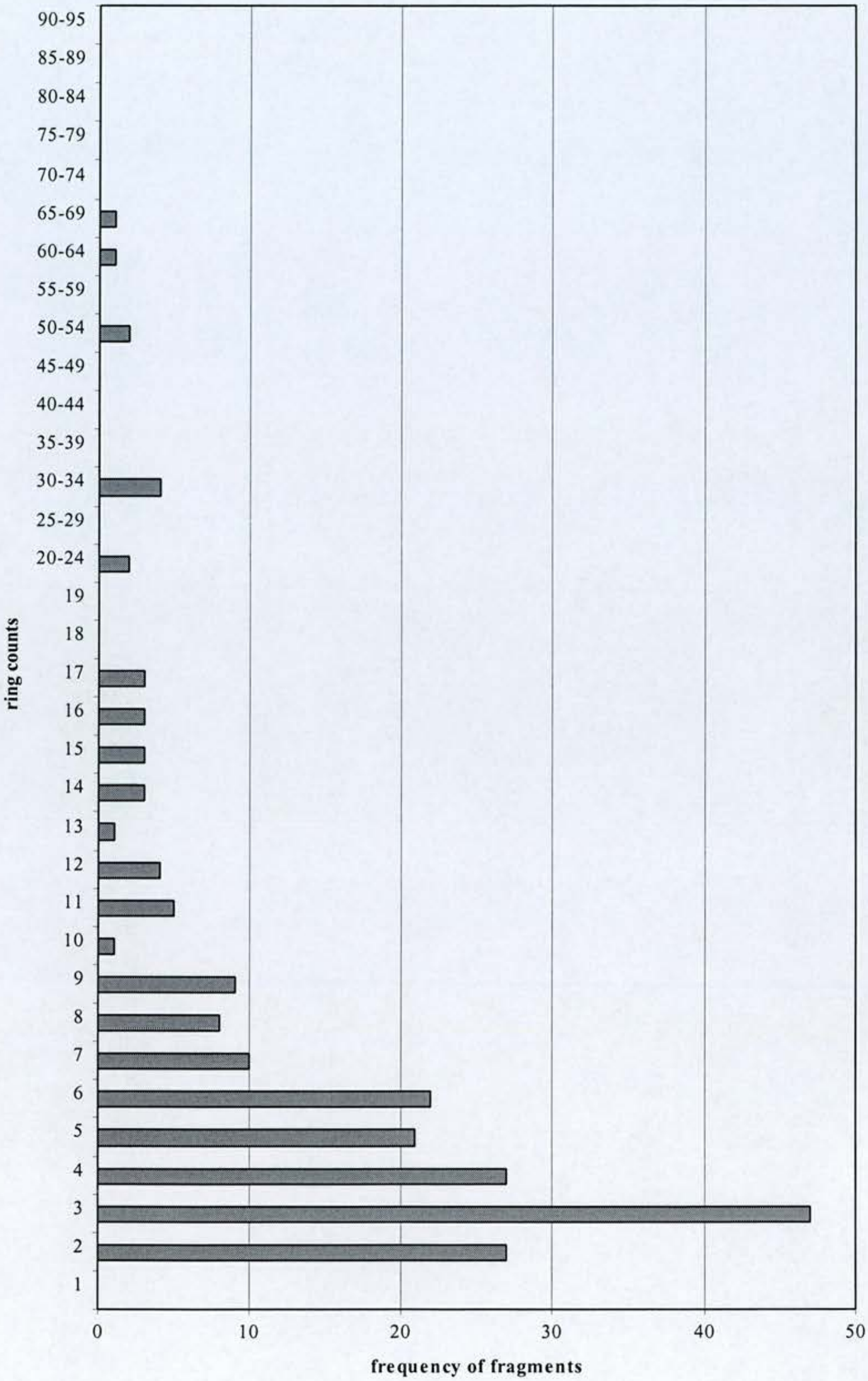


Figure 6.2: Ring counts of spruce charcoal fragments from conflagration in secondary structure at Dun Bharabhat (**DB-S**)

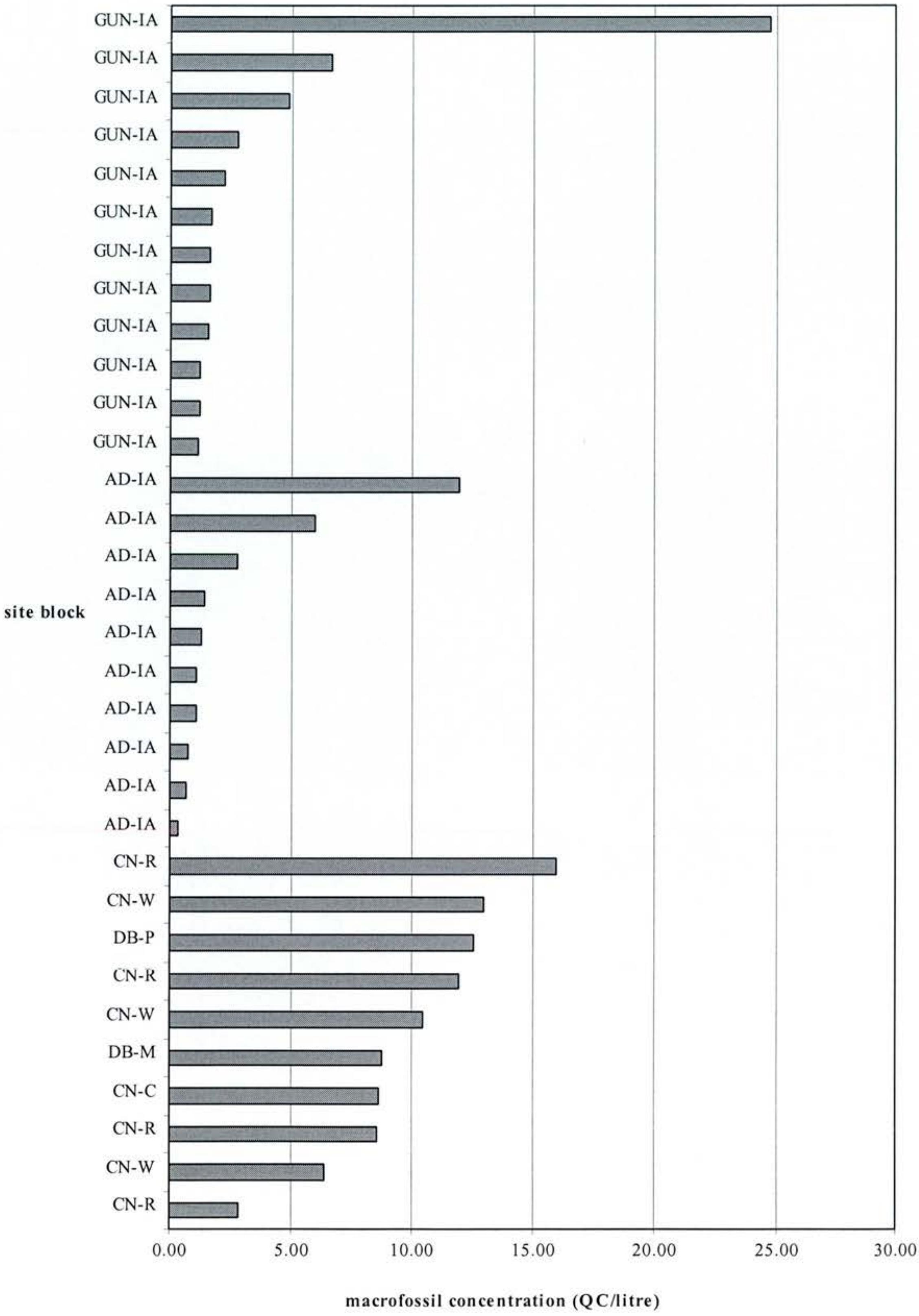


Figure 6.3: Macrofossil concentration (QC/litre) for each sample in the Mid Iron Age blocks from the Bhaltos and Uig Peninsulas

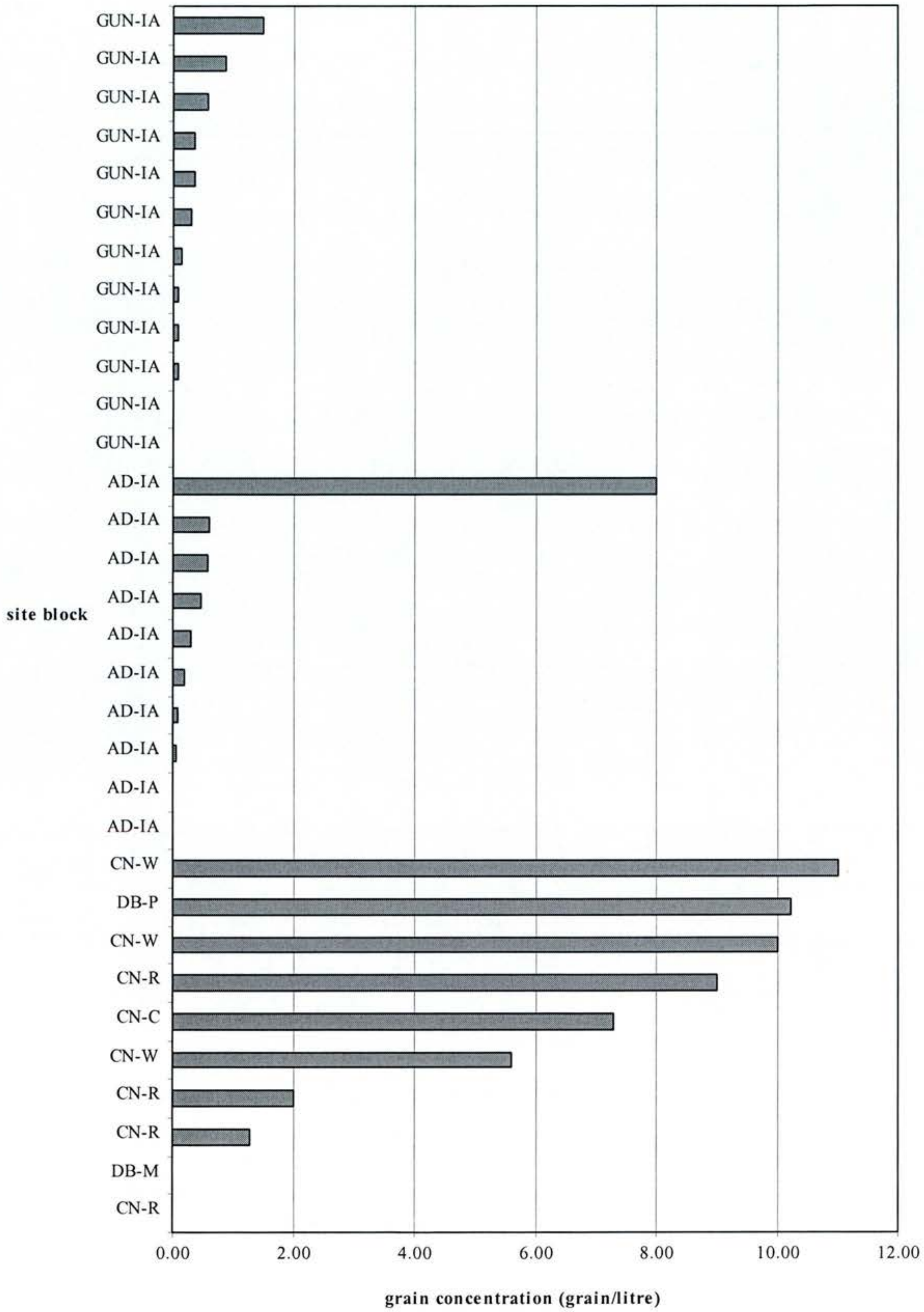


Figure 6.4: Grain concentration (caryopsis/litre) for each sample in the Mid Iron Age blocks from the Bhaltos and Uig Peninsulas

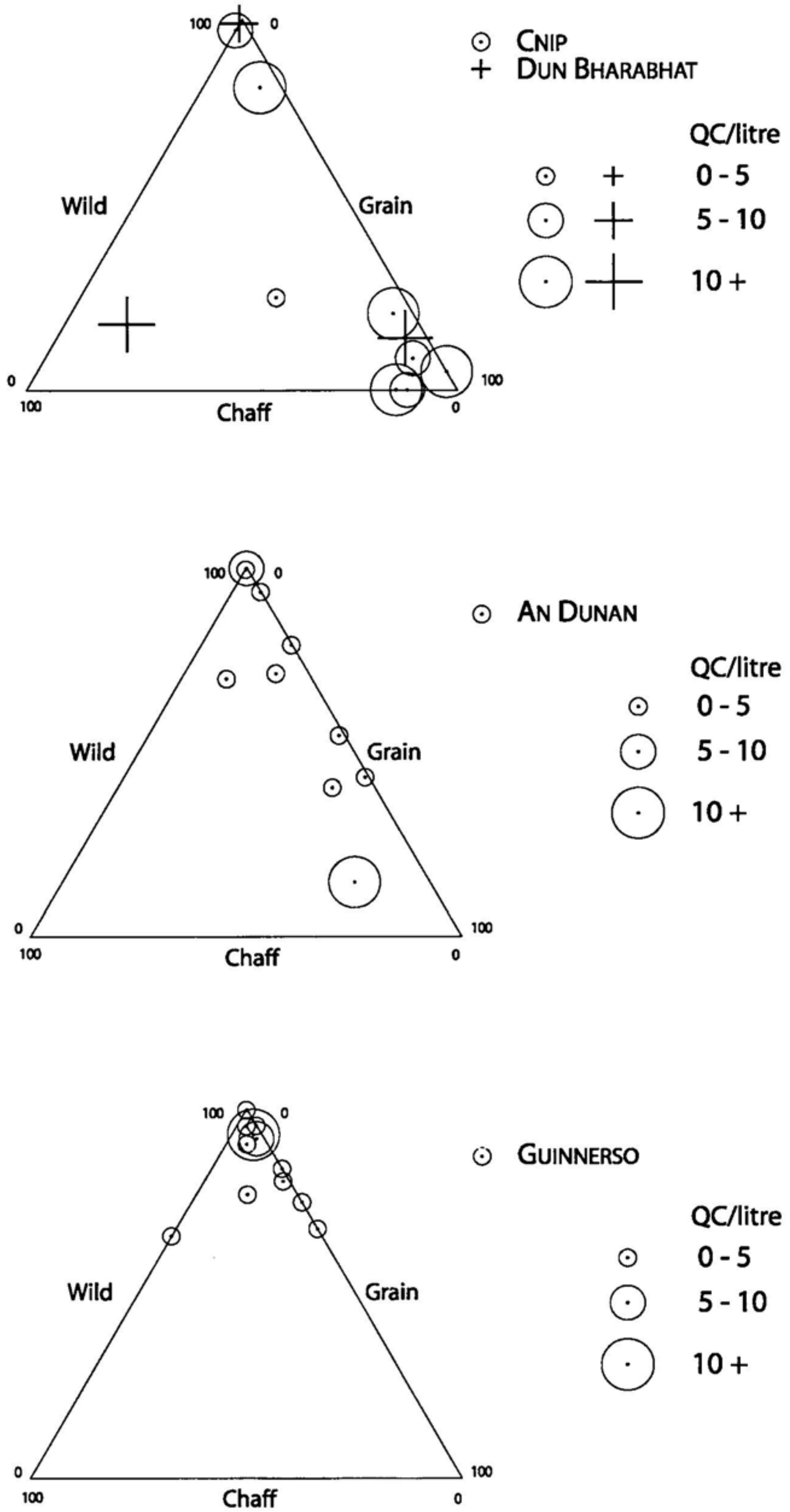


Figure 6.5: Triangular scattergrams for the Mid Iron Age blocks from the Bhaltos and Uig Peninsulas

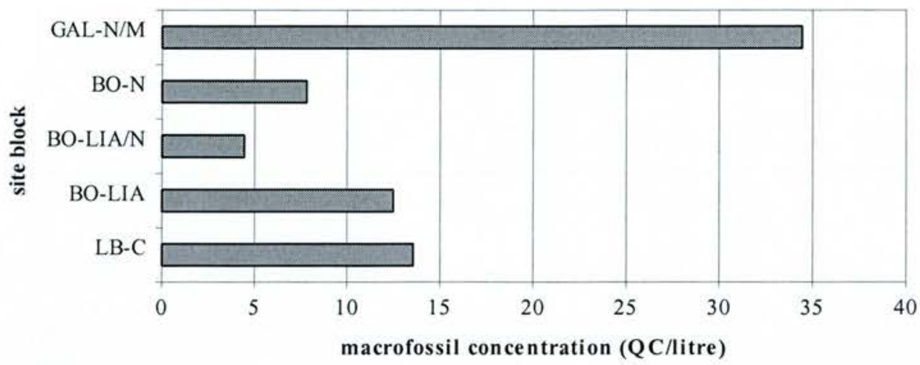


Figure 6.6: Average macrofossil concentration (QC/litre) for domestic blocks (greater than 10 samples in total)

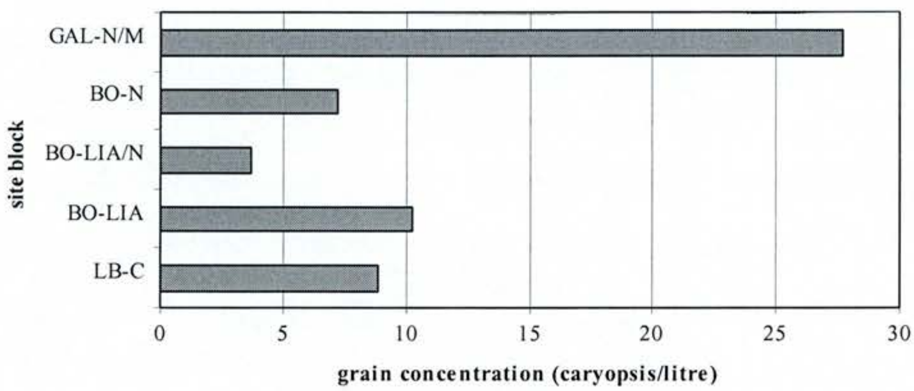


Figure 6.7: Average grain concentration (caryopsis/litre) for domestic blocks (greater than 10 samples in total)

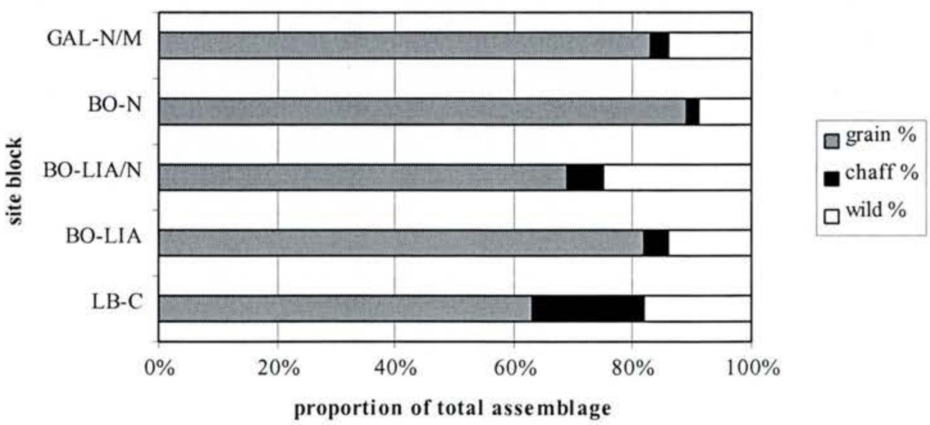


Figure 6.8: Total assemblage composition for domestic blocks (greater than 10 samples in total)

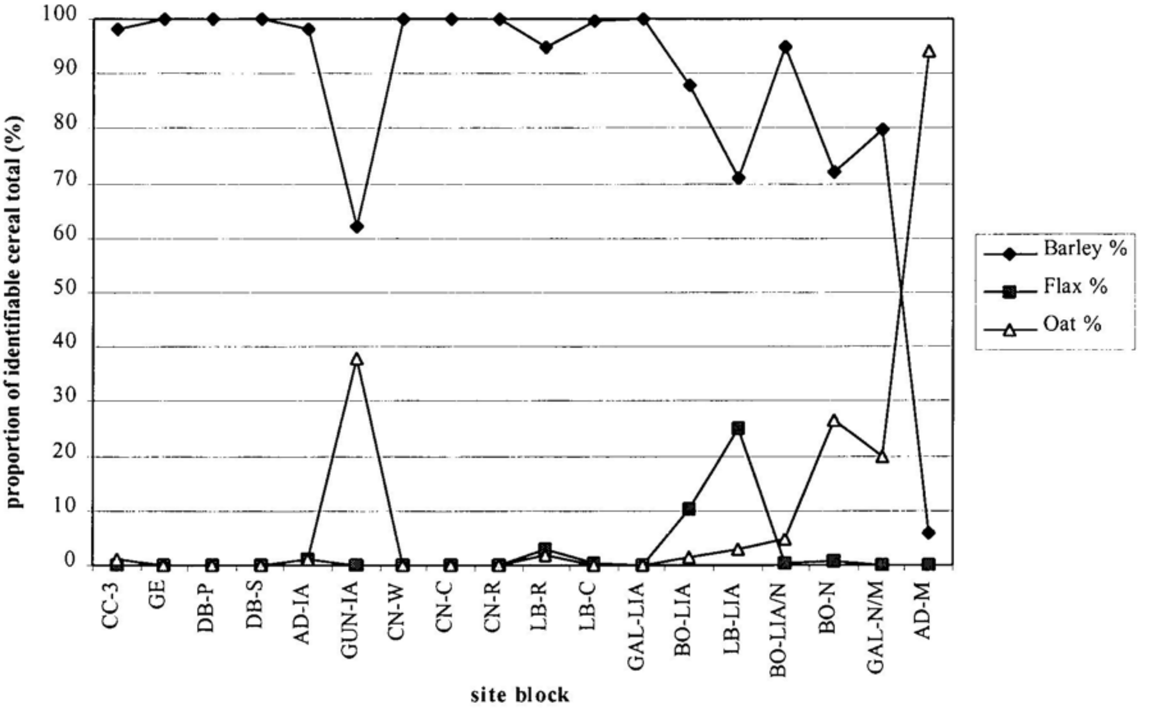


Figure 7.1: Proportions of identifiable cultivated genera from each site block with at least 10 identifiable seeds/grain

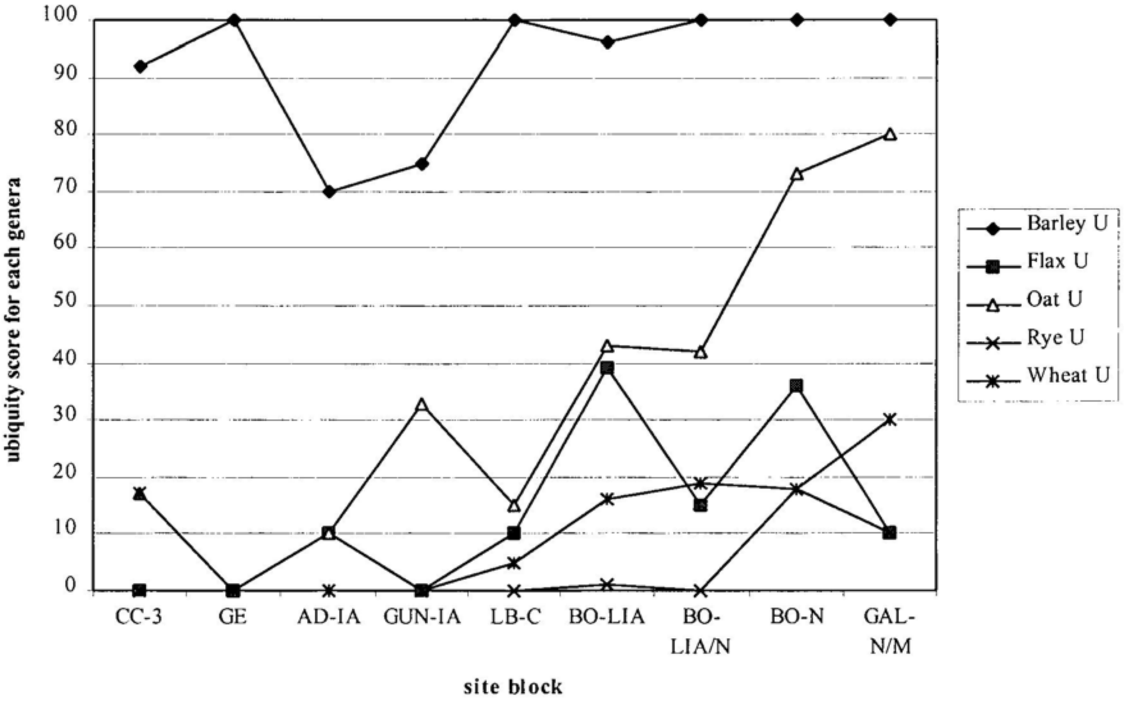


Figure 7.2: Ubiquity scores for each identifiable cultivated genera from each site block with at least 10 samples

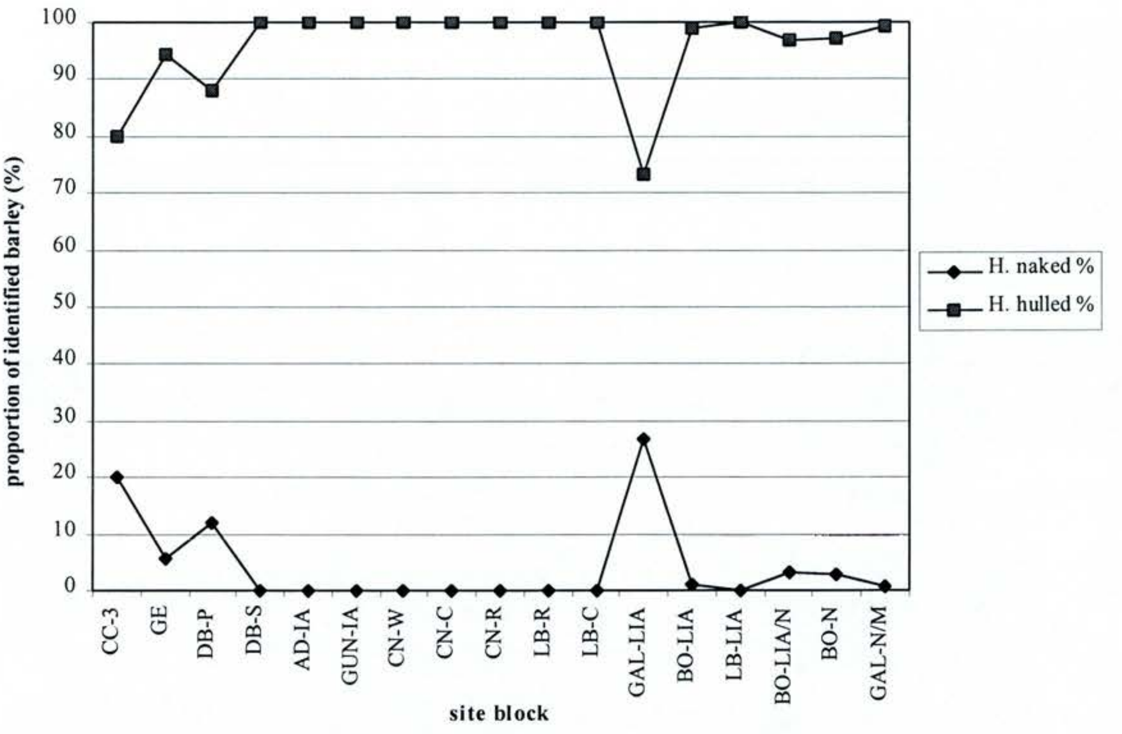


Figure 7.3: Ratio of hulled and naked barley from each site block with at least 10 identifiable barley grains

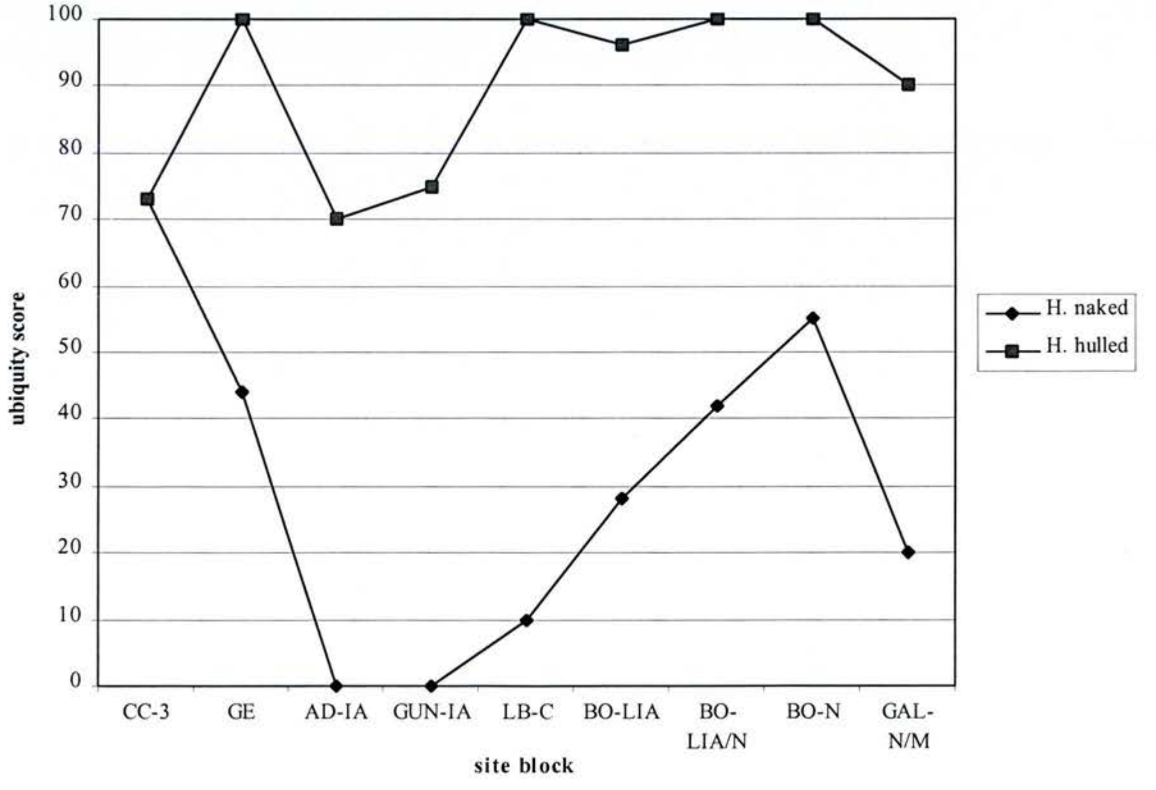


Figure 7.4: Ubiquity scores for hulled and naked barley from each site block with at least 10 samples

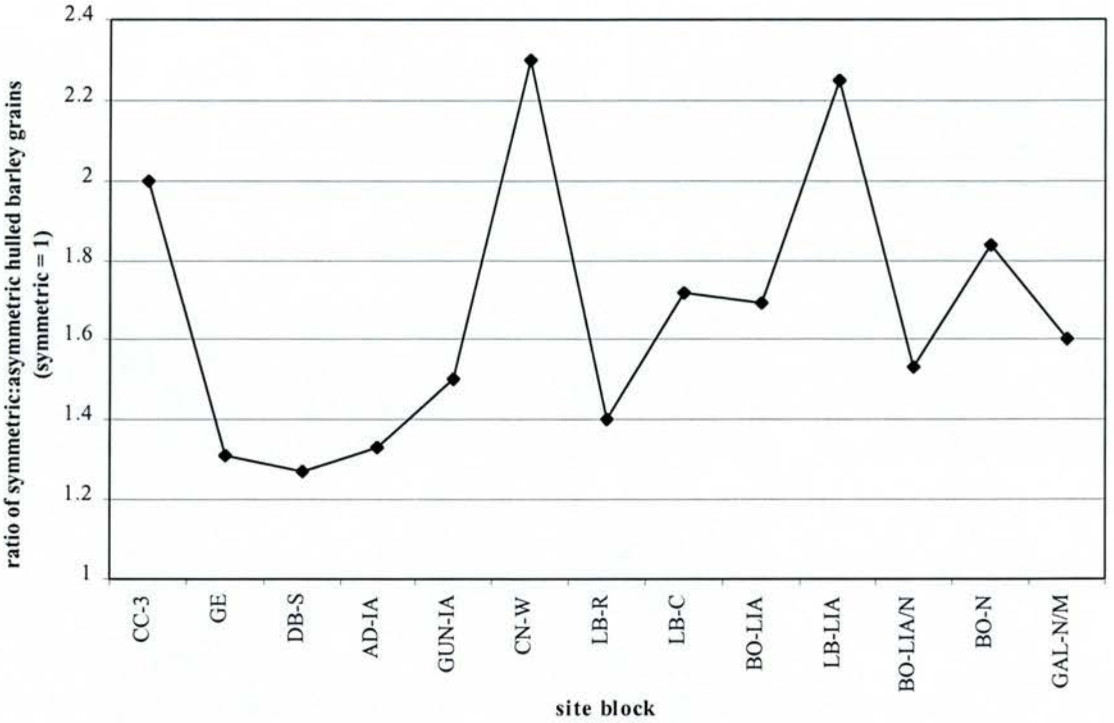


Figure 7.5: Ratio of symmetric:asymmetric hulled barley grain from each site block with at least 10 symmetric and asymmetric hulled barley grains

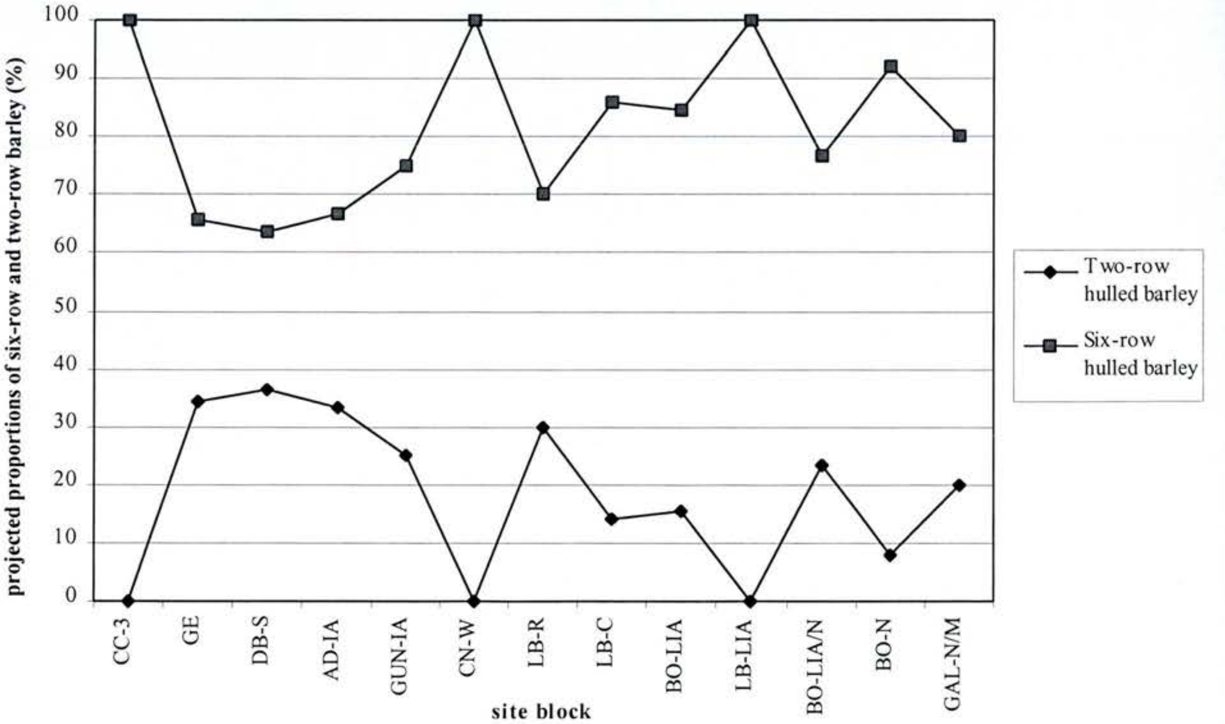


Figure 7.6: Projected proportions of six-row and two-row hulled barley calculated from ratio of symmetric:asymmetric grains with at least symmetric and assymmetric 10 grains

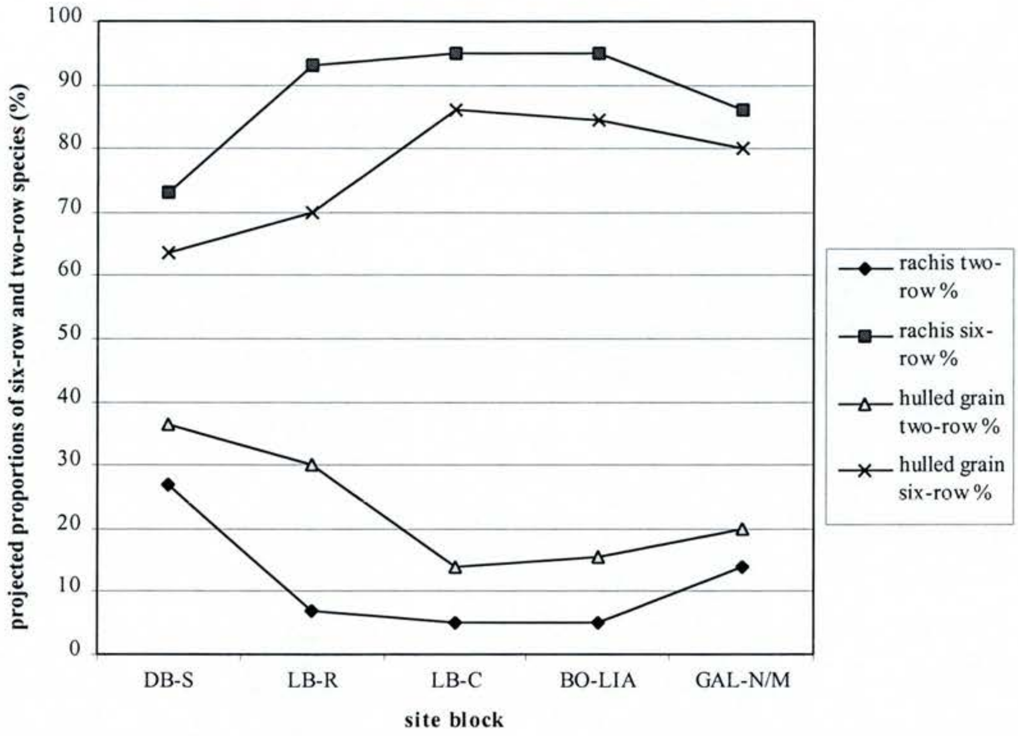


Figure 7.7: Projected proportions of six-row and two-row barley calculated from ratio of symmetric:asymmetric hulled grains and rachises from blocks with at least 10 grain and rachises

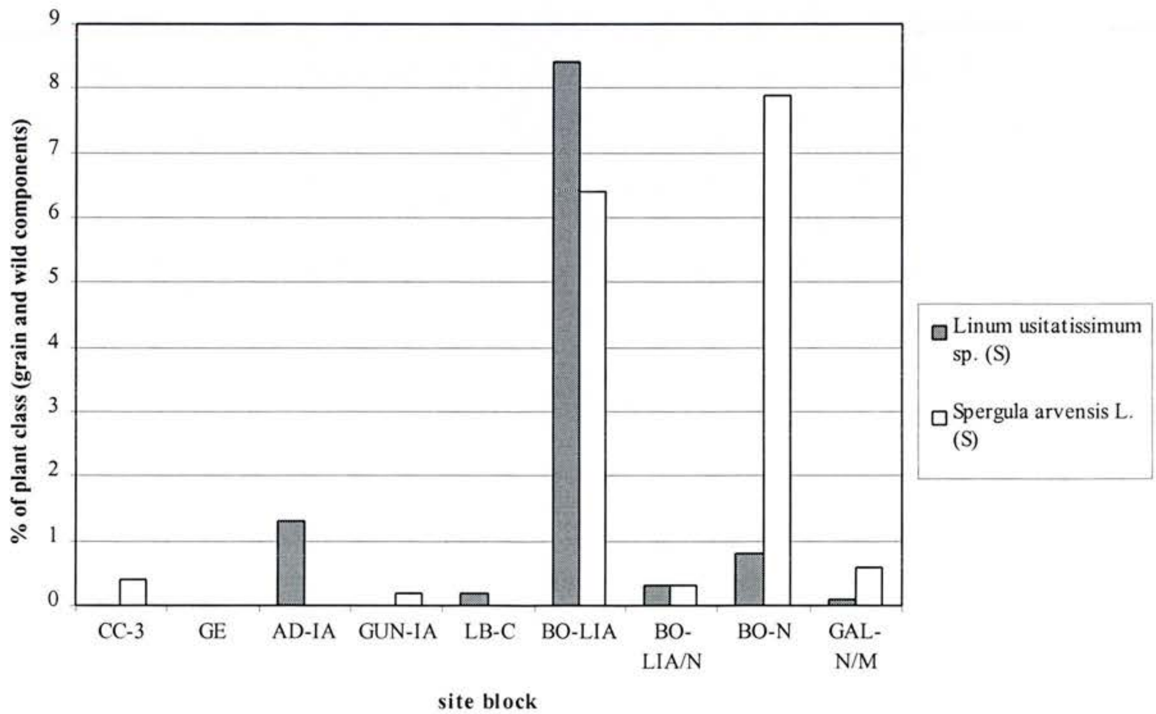


Figure 7.8: The correlation between the presence of flax and Corn spurrey from each site block with at least 10 samples (% of each plant class)

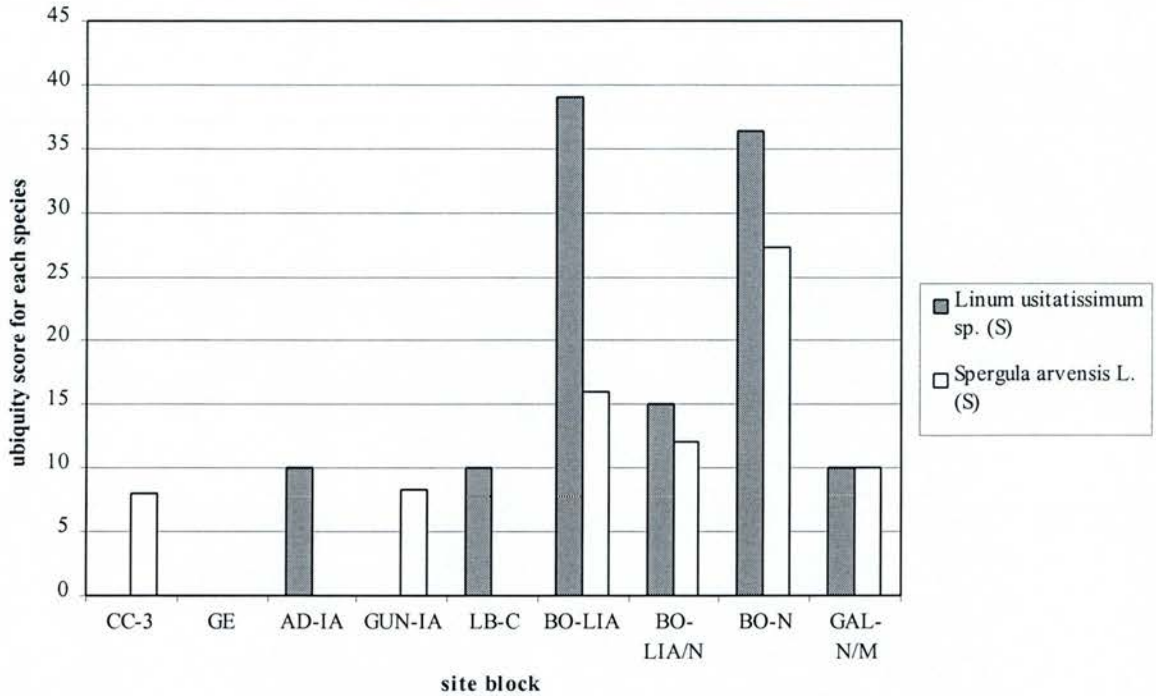


Figure 7.9: The correlation between the presence of flax and Corn spurrey from each site block with at least 10 samples (ubiquity score)

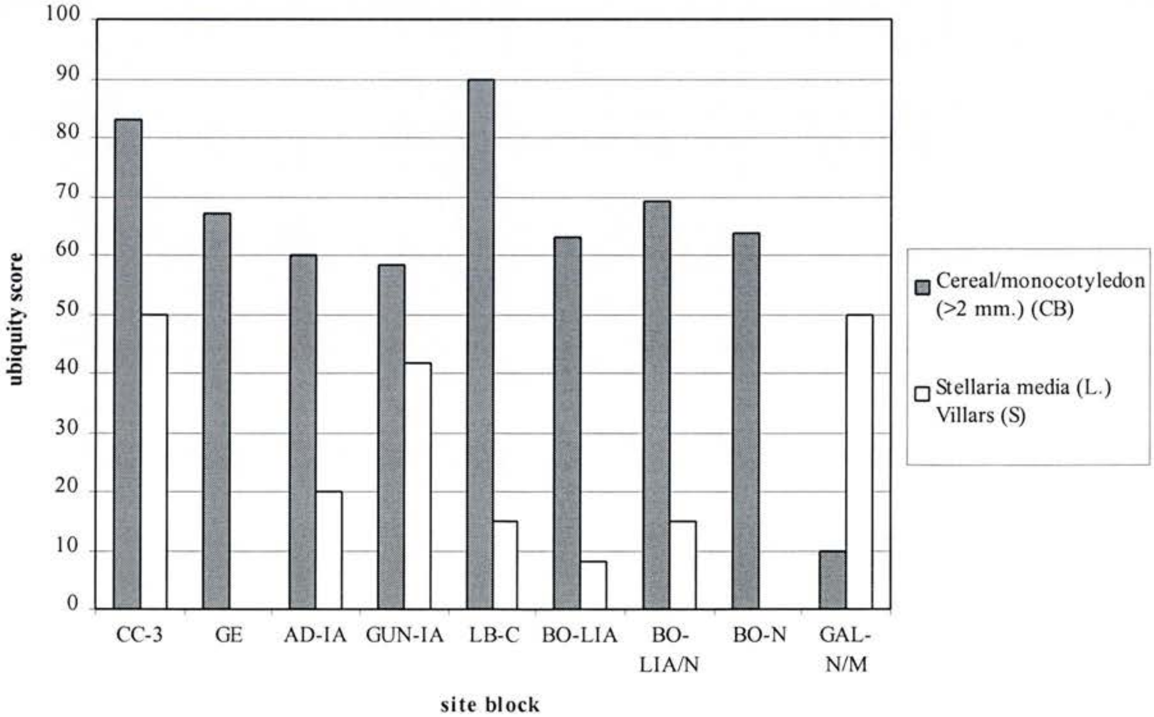


Figure 7.10: Ubiquity scores for large culm bases and Chick weed from each site block with at least 10 samples

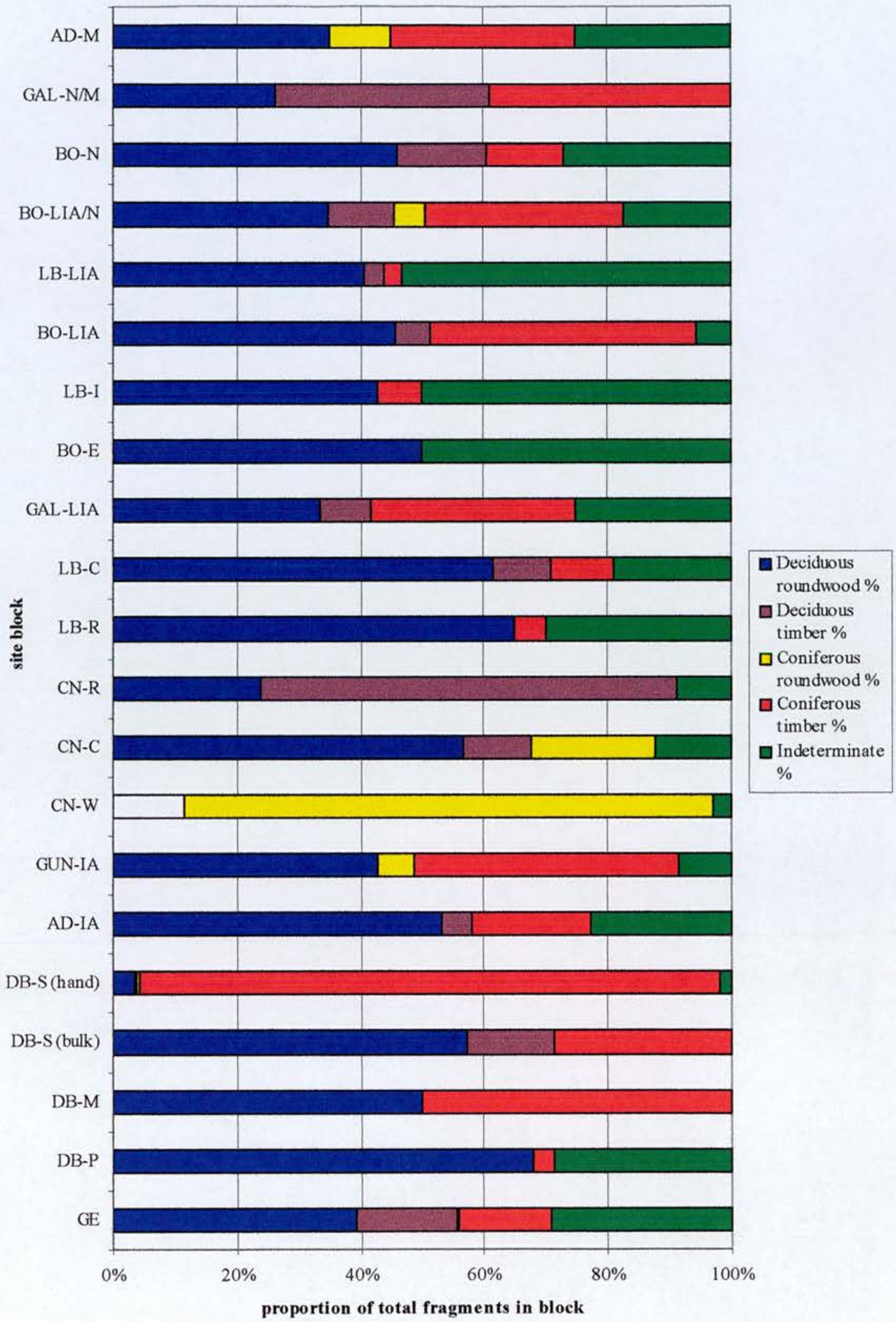


Figure 7.11: General composition of total charcoal fragments from each block

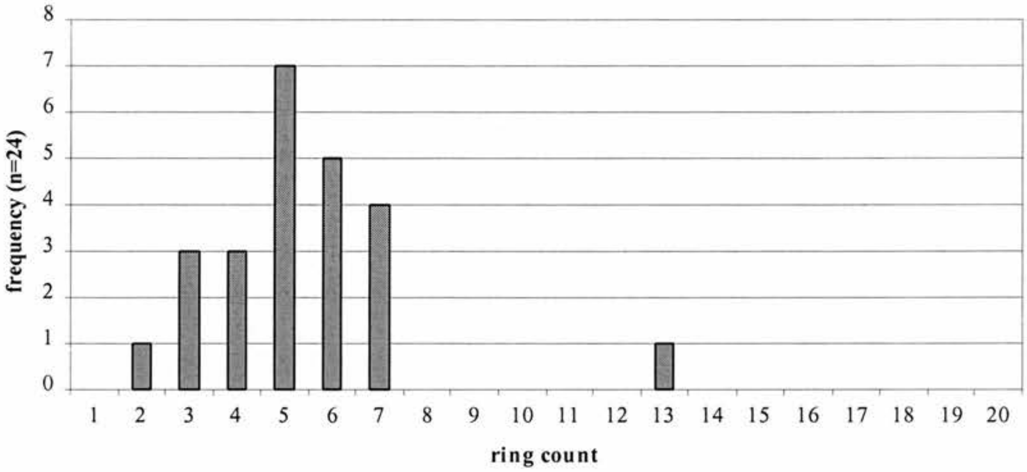


Figure 7.12: Ring counts for deciduous roundwood (pith to bark) from EIA blocks

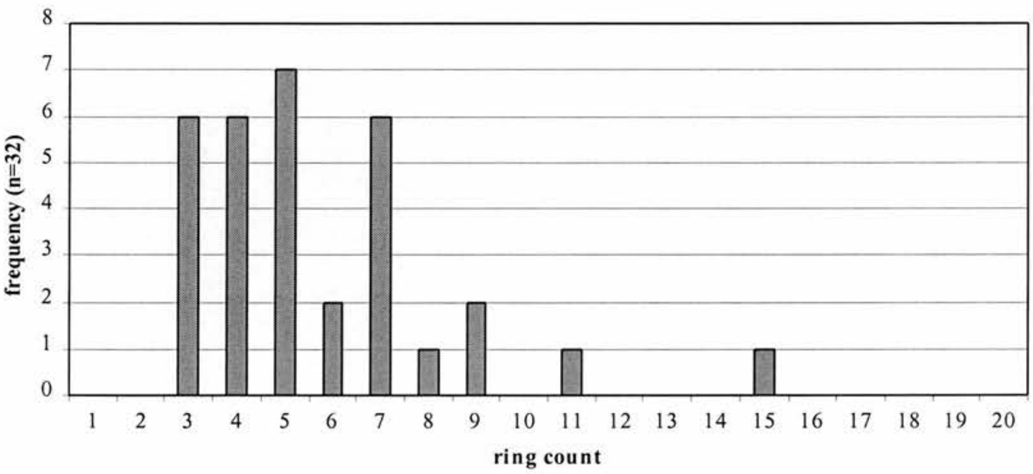


Figure 7.13: Ring counts for deciduous roundwood (pith to bark) from MIA blocks

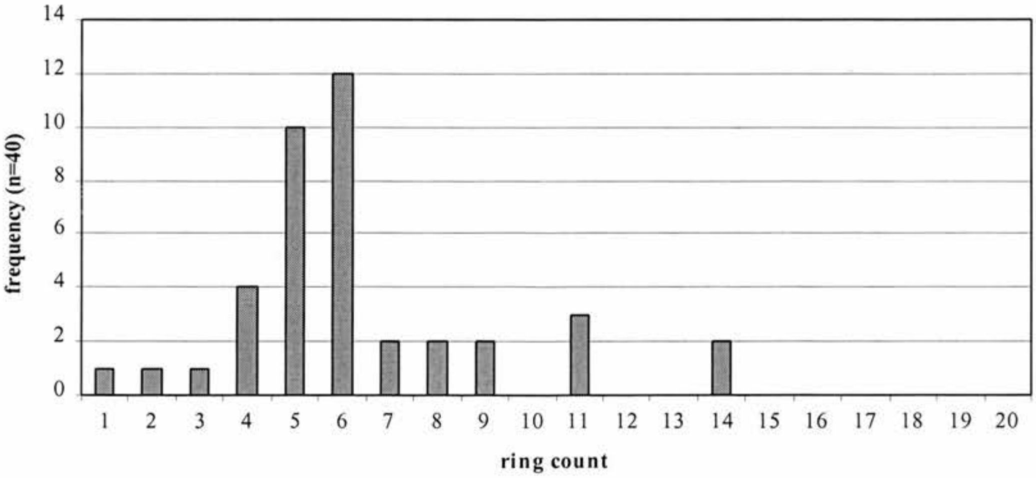


Figure 7.14: Ring counts for deciduous roundwood (pith to bark) from LIA-I blocks

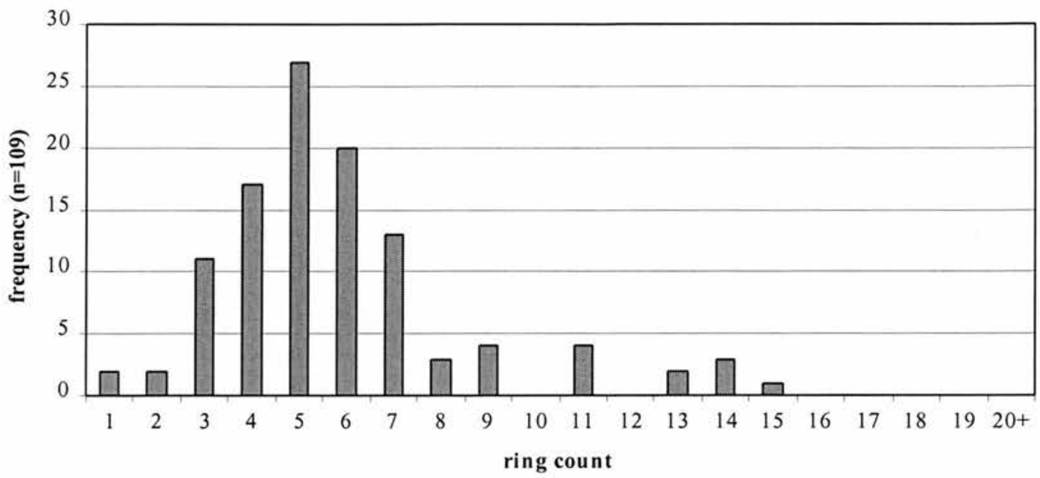


Figure 7.15: Ring counts for deciduous roundwood (pith to bark) from all blocks

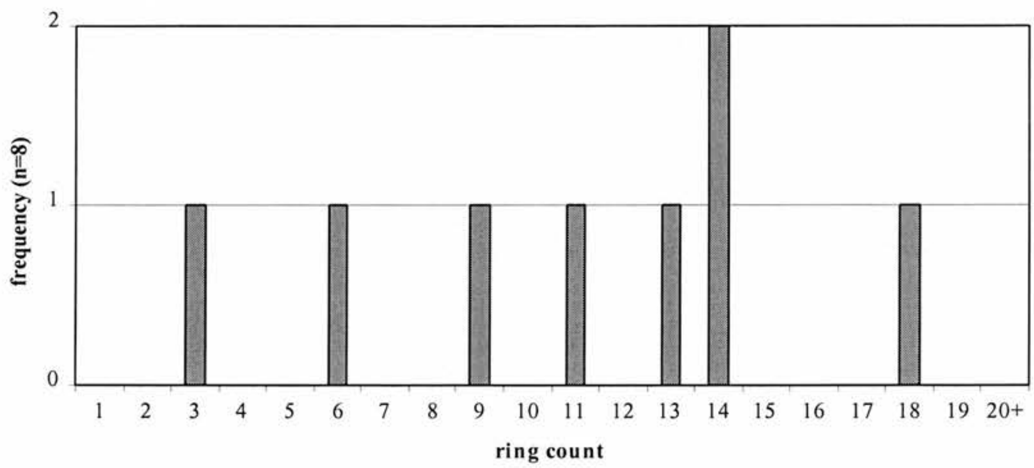


Figure 7.16: Ring counts for coniferous roundwood (pith to bark) from all blocks

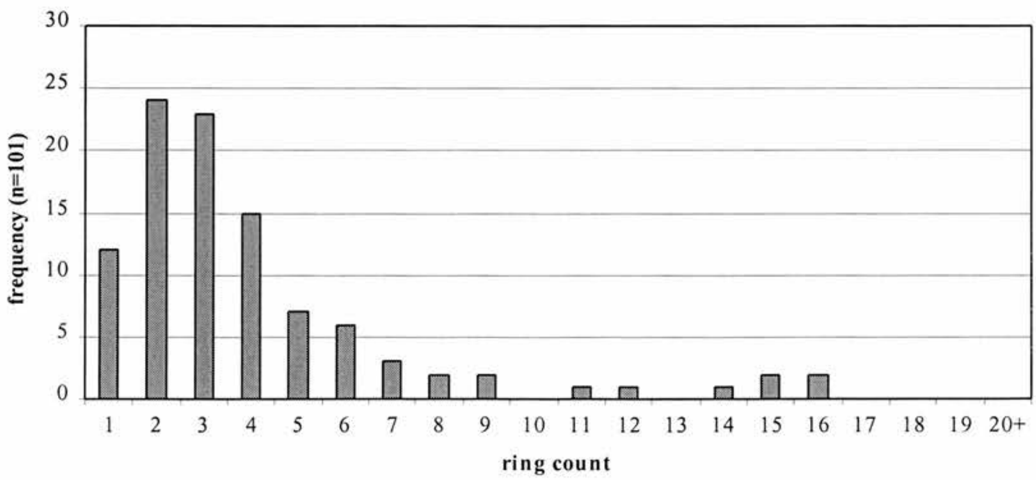


Figure 7.17: Ring counts for deciduous timber from all blocks

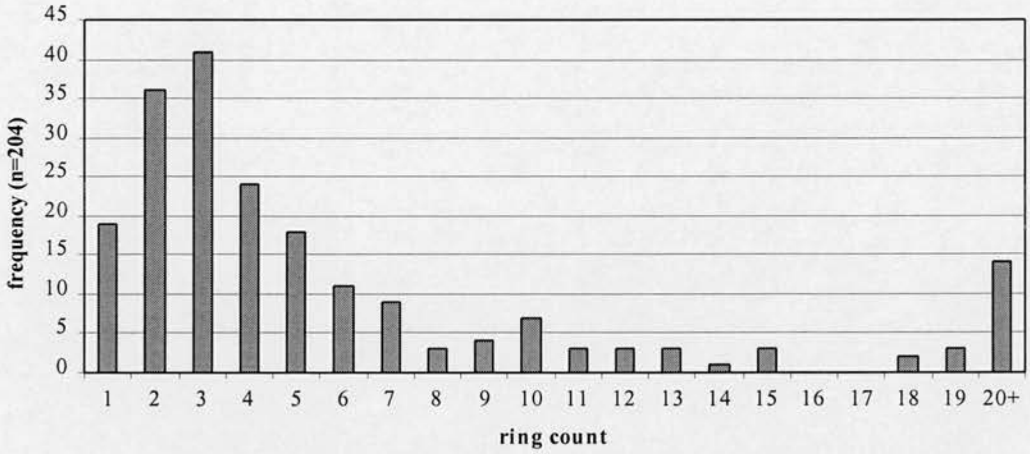


Figure 7.18: Ring counts for coniferous timber from all blocks (except **DB-S**)

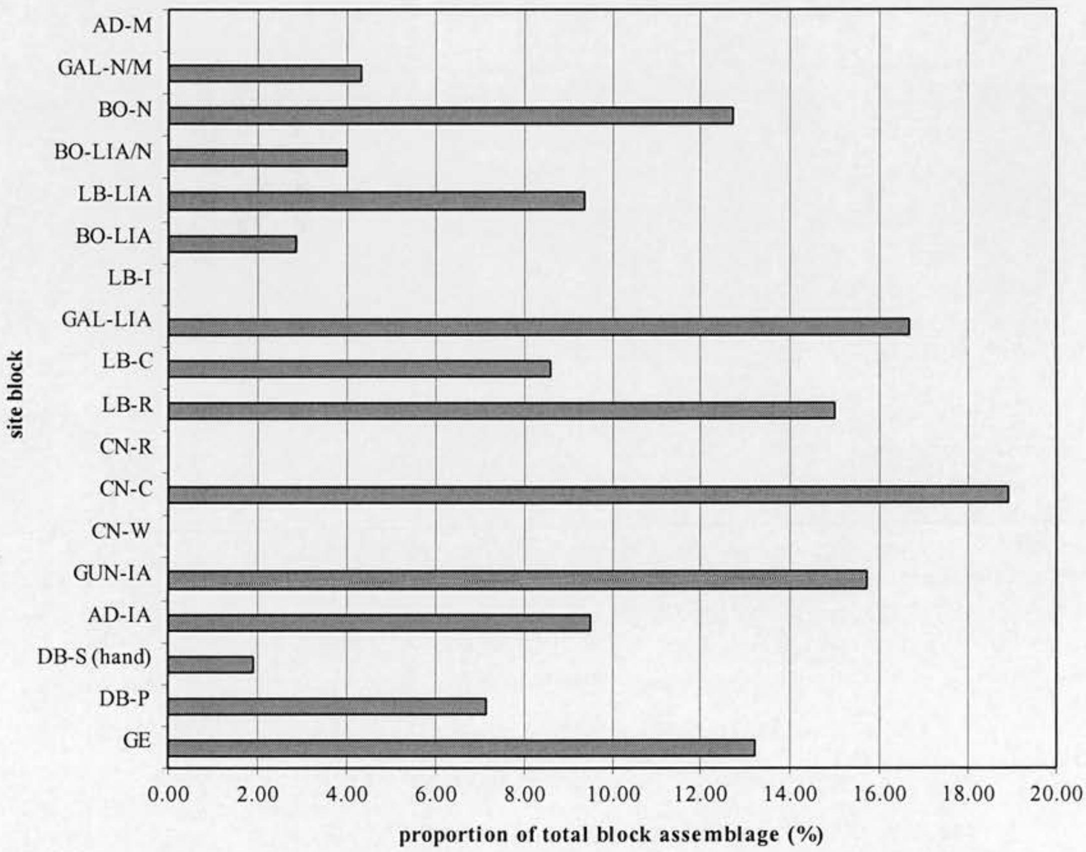


Figure 7.19: Birch roundwood as a proportion of the total assemblage for blocks with at least 10 charcoal fragments

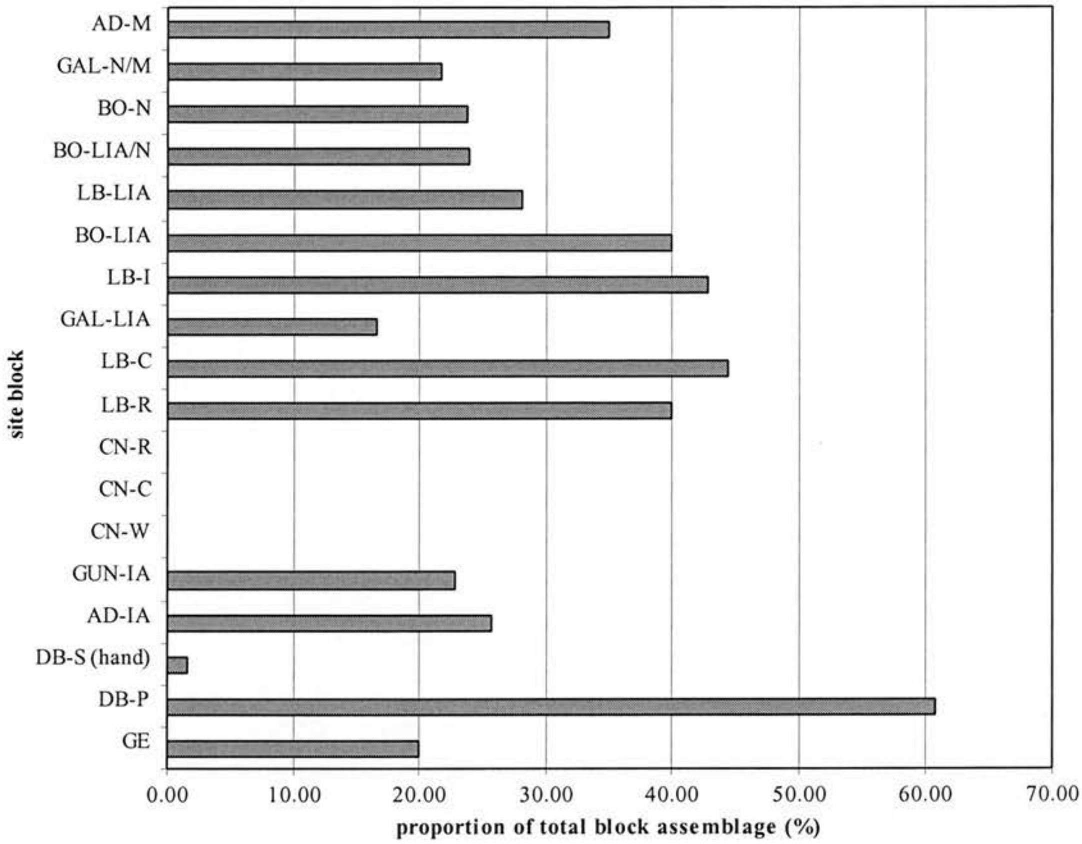


Figure 7.20: Ling heather roundwood as a proportion of the total assemblage for blocks with at least 10 charcoal fragments

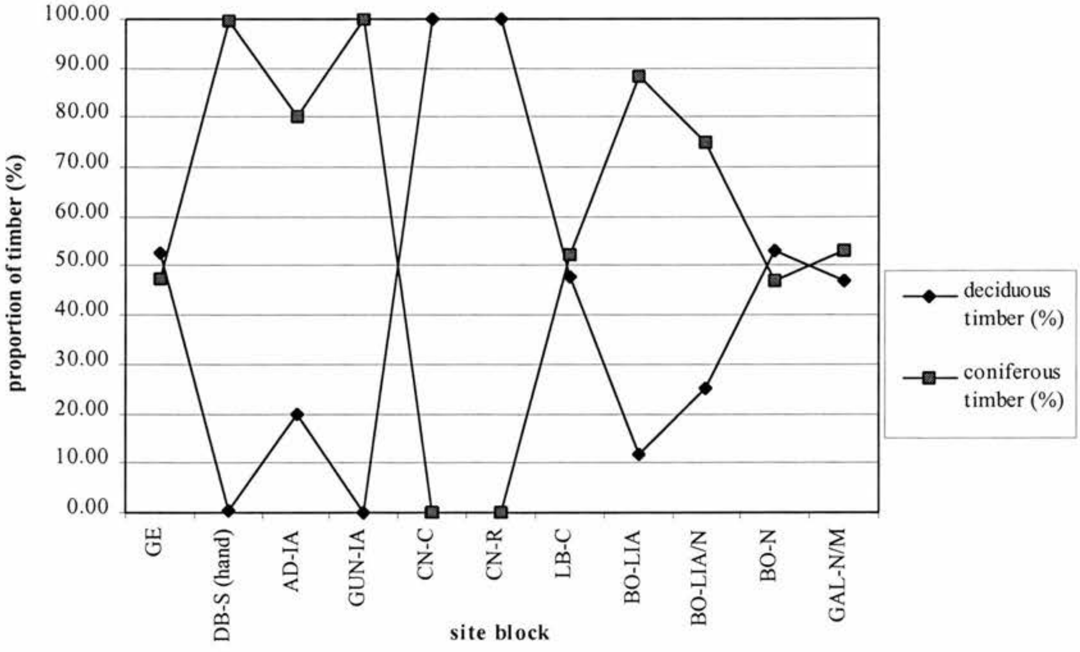


Figure 7.21: Proportions of deciduous and coniferous timber for blocks with at least 10 timber fragments

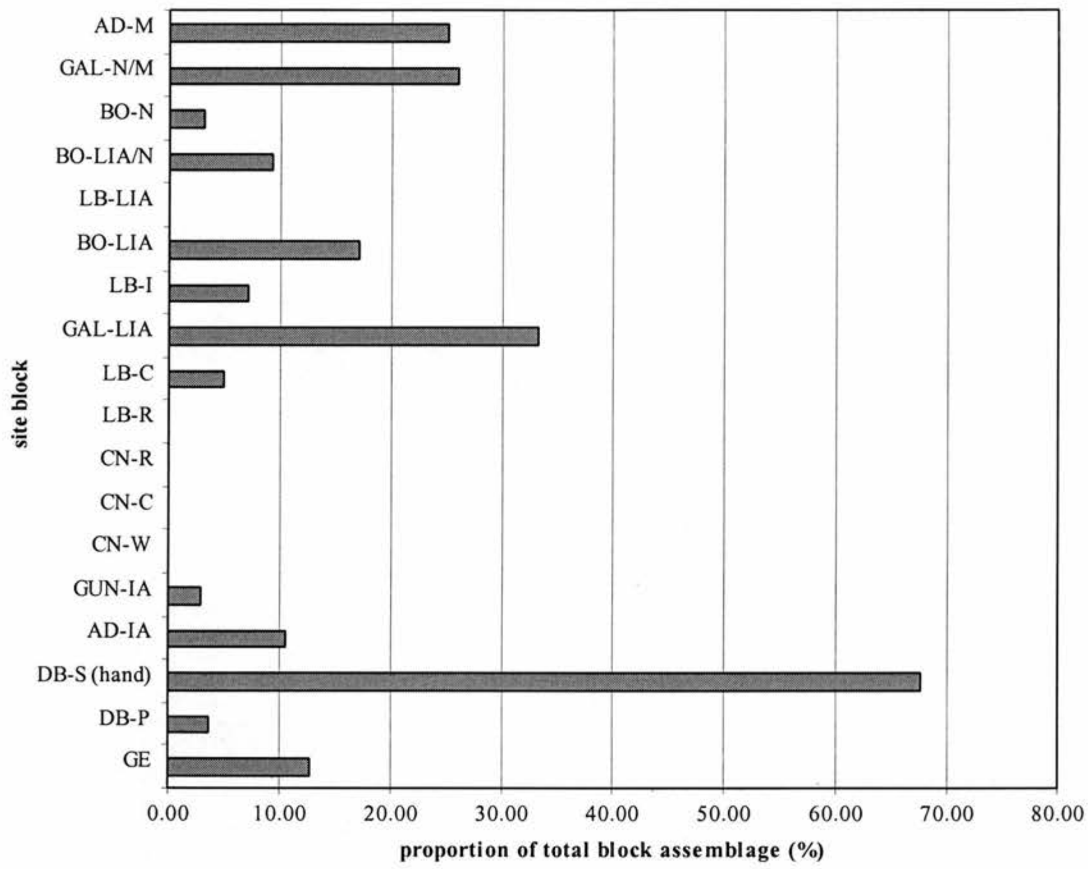


Figure 7.22: Pine timber as a proportion of the total assemblage for blocks with at least 10 charcoal fragments

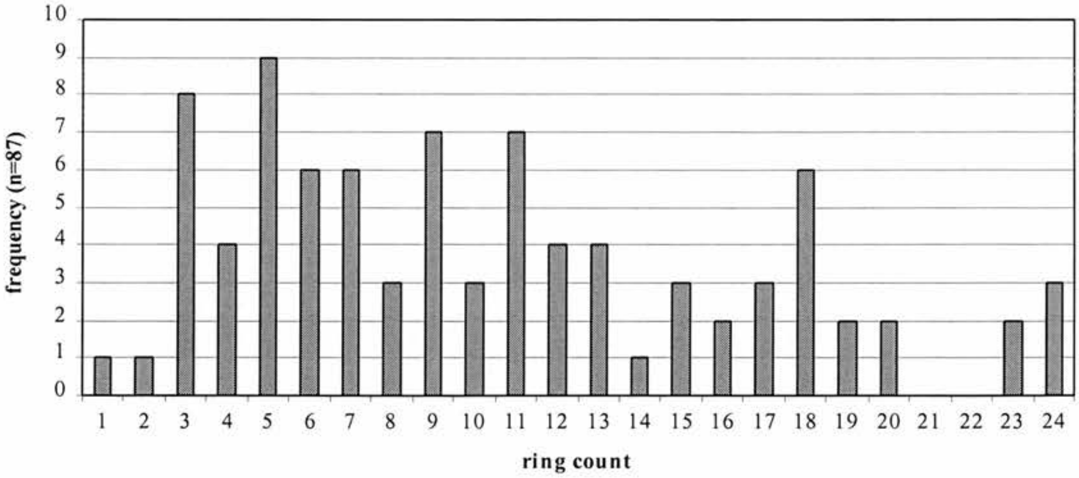


Figure 7.23: Ring counts for Ling heather (pith to bark) from EIA blocks

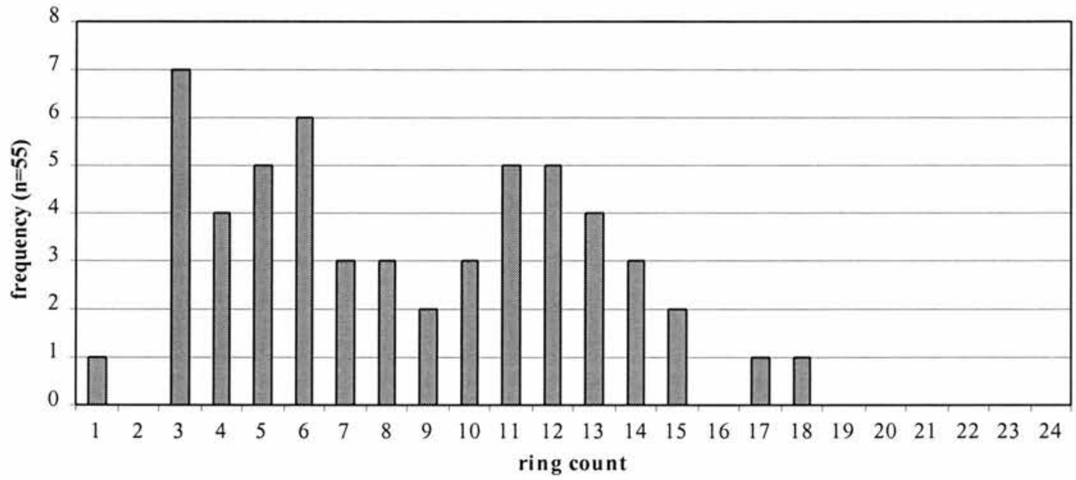


Figure 7.24: Ring counts for Ling heather (pith to bark) from MIA blocks

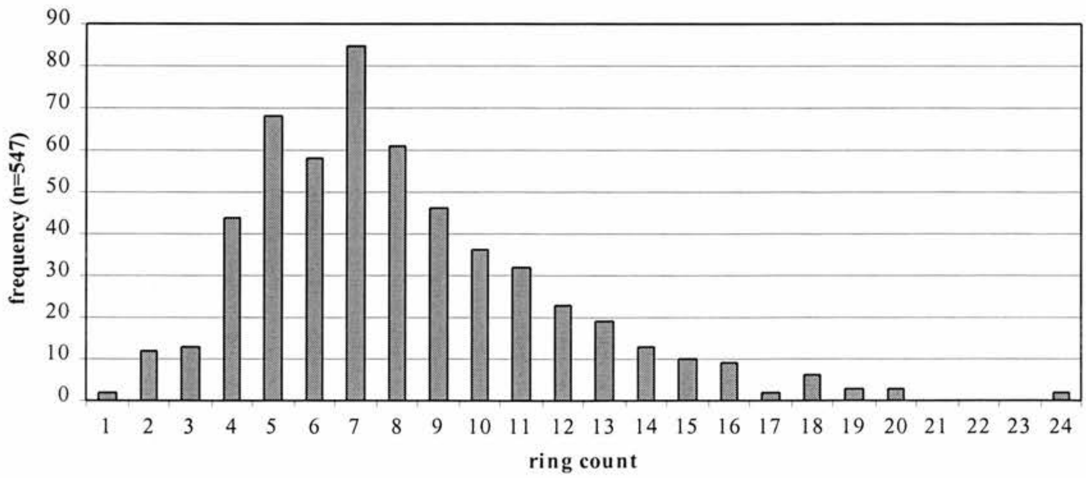


Figure 7.25: Ring counts for Ling heather (pith to bark) from LIA-I blocks

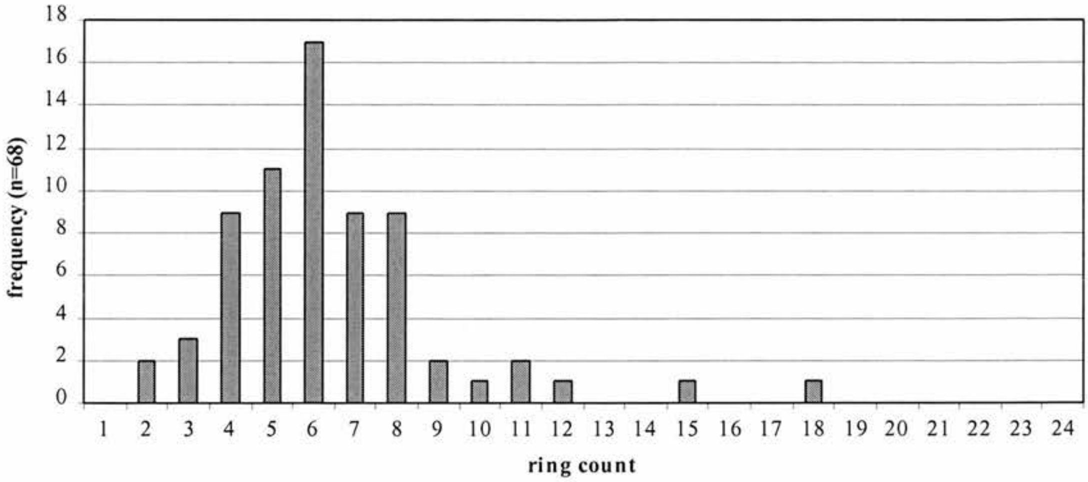


Figure 7.26: Ring counts for Ling heather (pith to bark) from LIA-II blocks

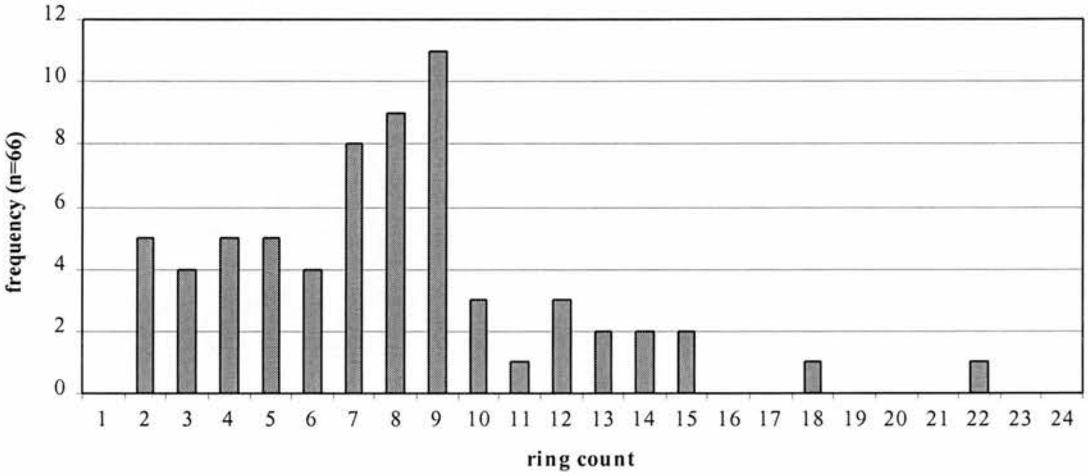


Figure 7.27: Ring counts for Ling heather (pith to bark) from BO-LIA/N block

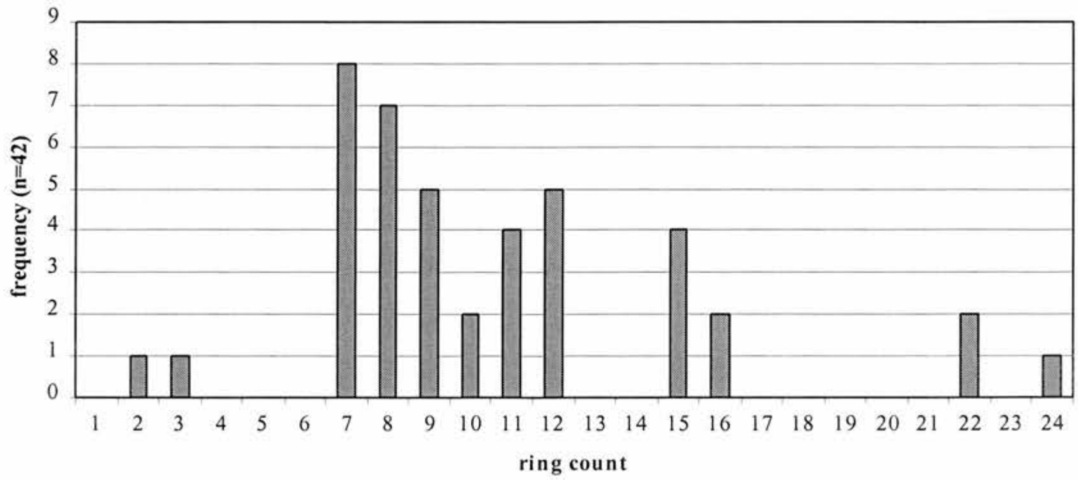


Figure 7.28: Ring counts for Ling heather (pith to bark) from N/EM blocks

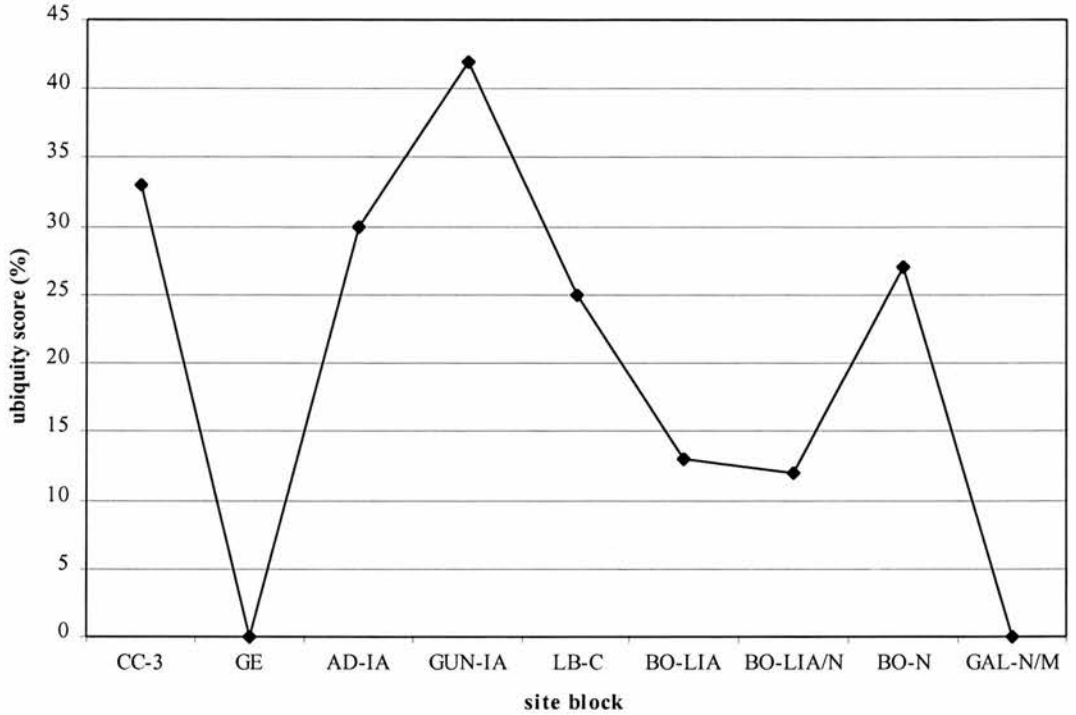


Figure 7.29: Ubiquity scores for moorland berried plants from each site block with at least 10 samples

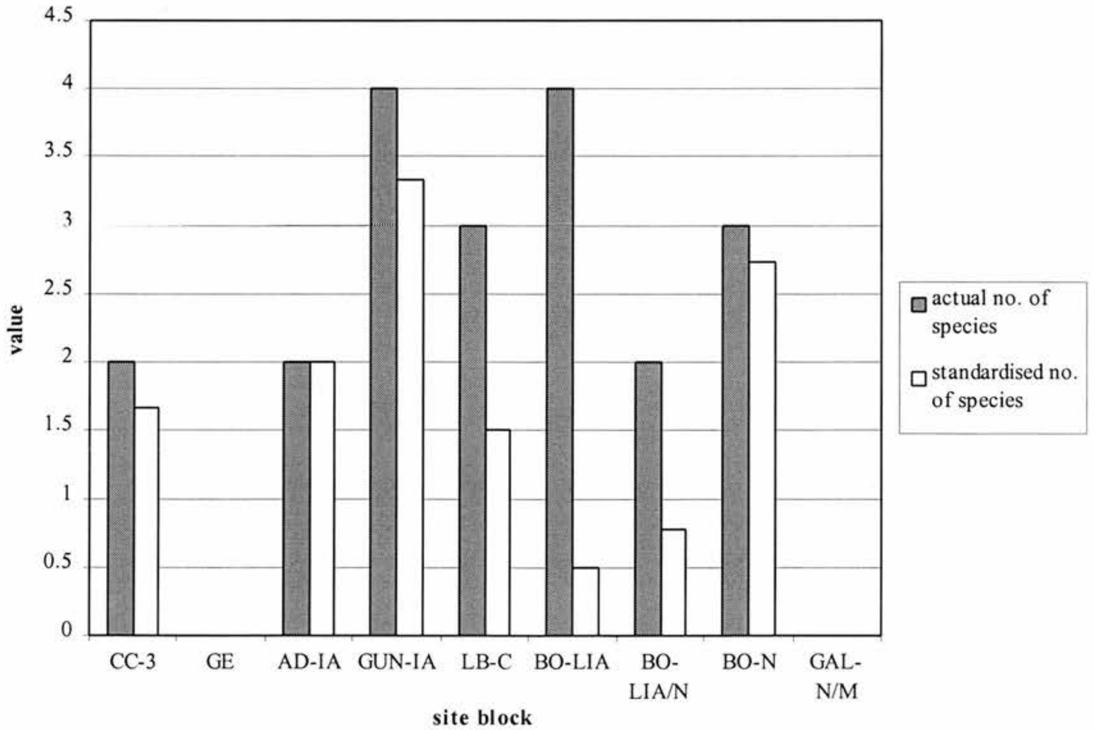


Figure 7.30: Number of species of berried plants (actual and standardised value) from each site block with at least 10 samples

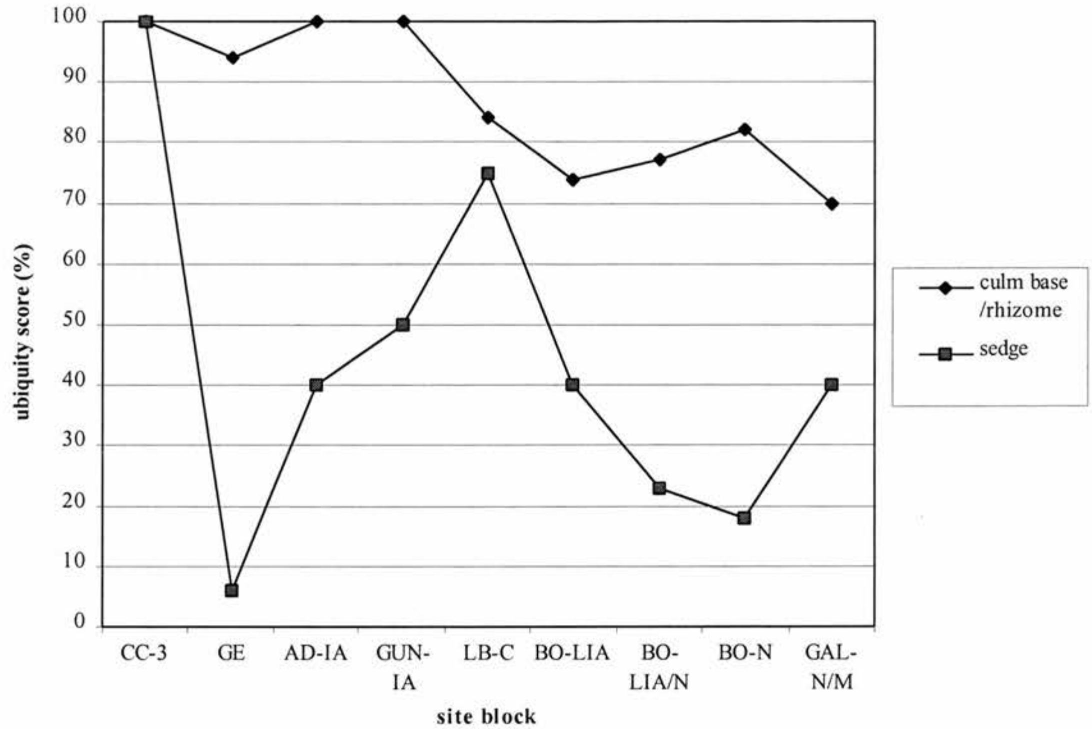


Figure 7.31: Ubiquity scores of small culm bases/rhizomes and sedges from each site block with at least 10 samples

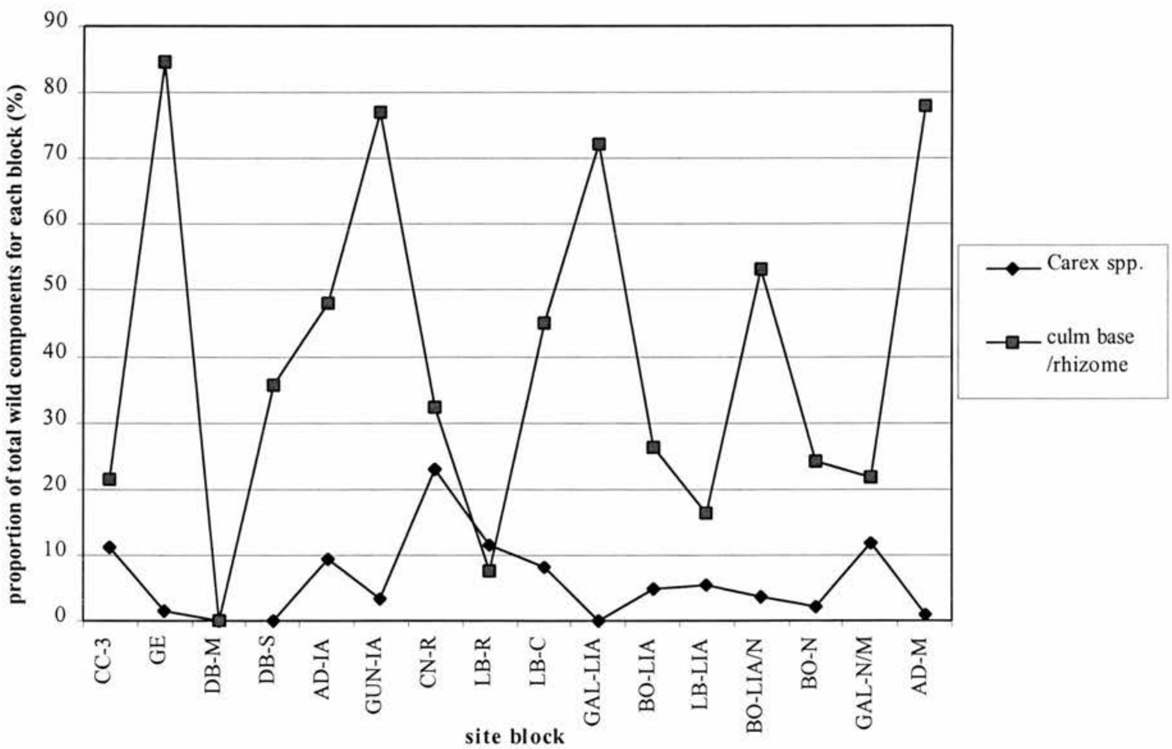


Figure 7.32: Proportion of small culm bases/rhizomes and sedges for the wild components from each site block with at least 10 wild components

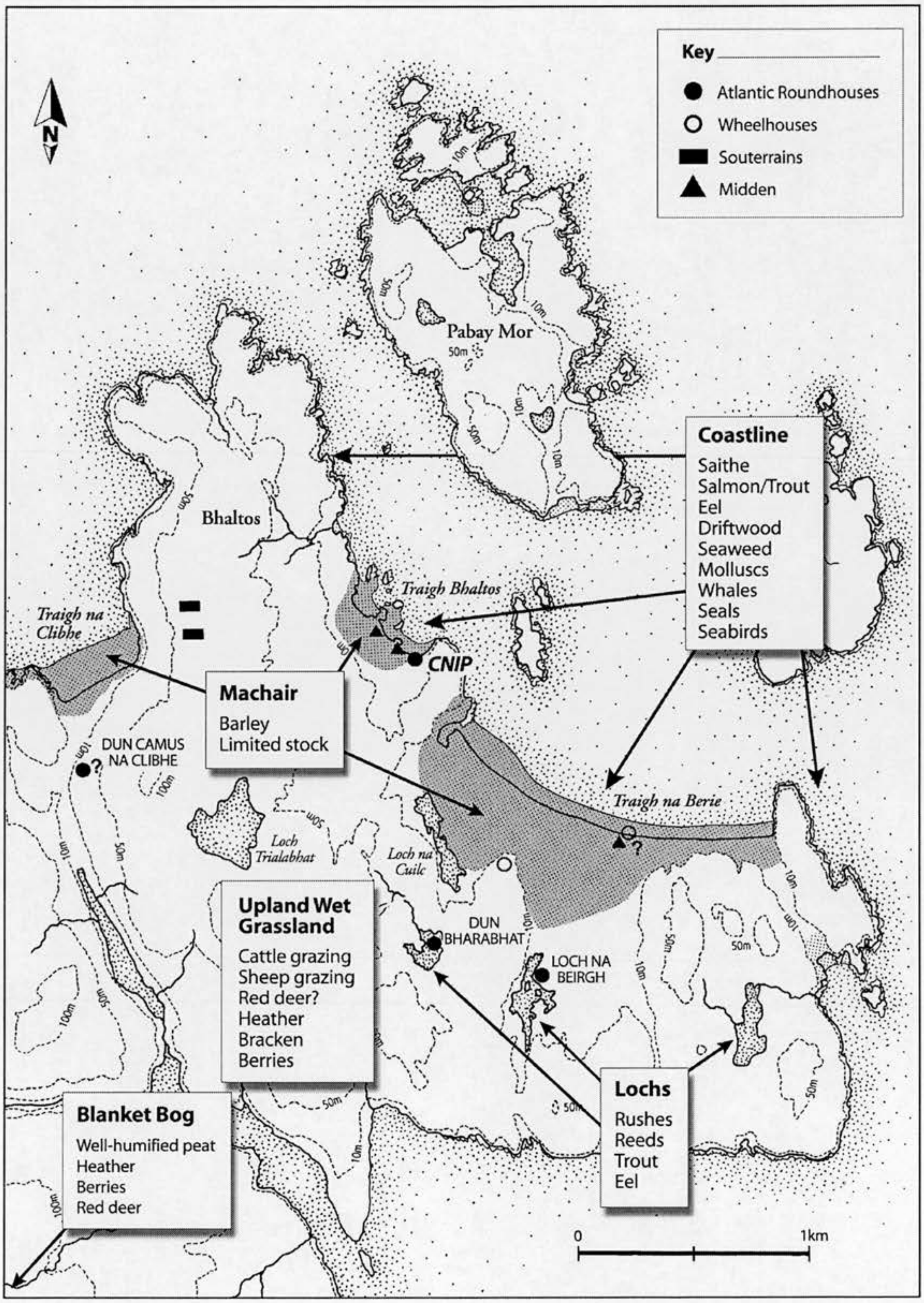


Figure 7.33: Landscape reconstruction for Bhaltos Peninsula (Source: Ceron-Carrasco *et al.*, forth.)

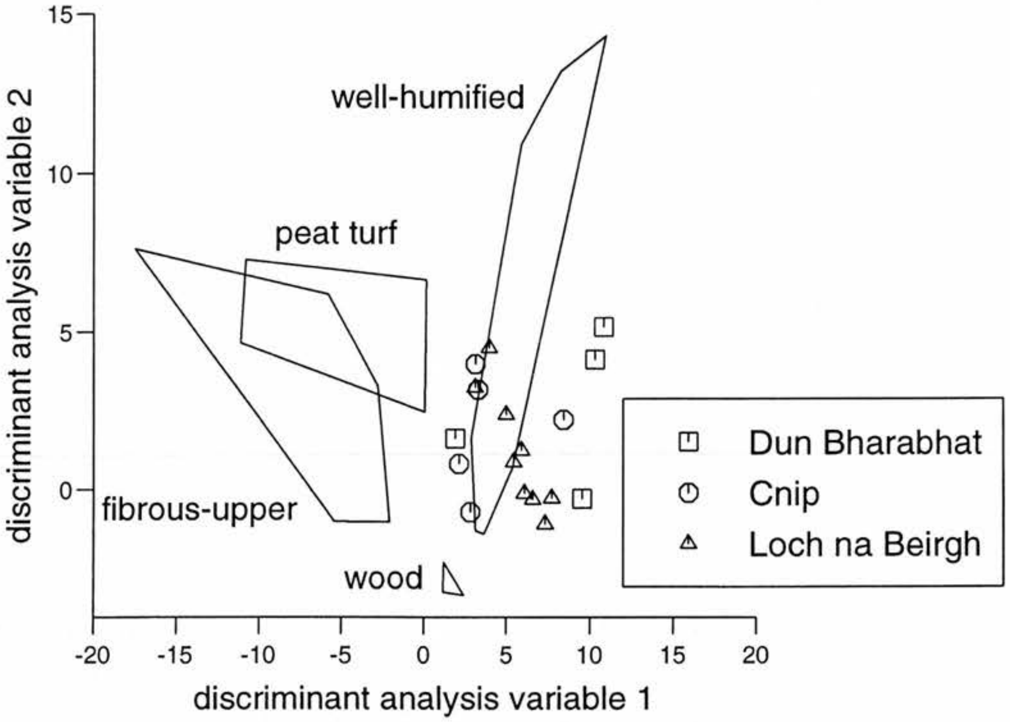


Figure 7.34: Discriminant analysis biplot of ash samples from Bhaltos Peninsula (Source: Ceron-Carrasco *et al.*, forth.)

Resource	Early Spring	Late Spring	Early Summer	Late Summer	Autumn	Winter
Core area						
Barley	'Ploughing' and sowing	Weeding	Weeding	Harvesting and processing	Soil amendment	Stabilising soil
Managed woodland	Hazel coppicing			Foliage extraction for fodder	Hazelnut gathering	
Coastline zone (driftwood and seaweed extracted throughout year)	Driftwood optimum (storms)		Seaweed optimum	Seaweed optimum	Driftwood optimum (storms)	Driftwood optimum (storms)
Immediate hinterland						
Fodder production from rough grazing			Bracken optimum	Sedge and grass optimum		
Inaccessible woodland (cliffs and islands)	Opportunistic removal of branchwood			Foliage extraction for fodder	Hazelnut gathering	
Moorland						
Transhumance			Transhumance	Transhumance		
Peat extraction	Peat cutting / stacking	Peat drying	Peat drying / collection	Peat collection / stacking		
Heather	Possible fire ecology		Optimum gathering	Optimum gathering		
Berried plants				Optimum gathering	Late gathering	

Figure 7.35: Seasonal cycle for plant procurement and management from the Mid to Late Iron Age I

Resource	Early Spring	Late Spring	Early Summer	Late Summer	Autumn	Winter
Core area						
Barley	'Ploughing' and sowing	Weeding	Weeding	Harvesting and processing	Soil amendment	Stabilising soil
Flax	'Ploughing' and sowing	Weeding	Weeding	Harvesting and seed extraction	Fibre retting	Further processing and spinning of fibre
Managed woodland	Hazel coppicing			Foliage extraction for fodder	Hazelnut gathering	
Coastline zone (driftwood and seaweed extracted throughout year)	Driftwood optimum (storms)		Seaweed optimum	Seaweed optimum	Driftwood optimum (storms)	Driftwood optimum (storms)
Immediate hinterland						
Oat	'Ploughing' and sowing	Possible weeding	Possible weeding	Harvesting and processing		
Fodder production from rough grazing			Bracken optimum	Sedge and grass optimum		
Inaccessible woodland (cliffs and islands)	Opportunistic removal of branchwood			Foliage extraction for fodder	Hazelnut gathering	
Moorland						
Transhumance			Transhumance	Transhumance		
Peat extraction	Peat cutting / stacking	Peat drying	Peat drying / collection	Peat collection / stacking		
Heather	Fire ecology?		Optimum gathering	Optimum gathering		
Berried plants				Optimum gathering	Late gathering	

Figure 7.36: Seasonal cycle for plant procurement and management from the Late Iron Age II to Norse

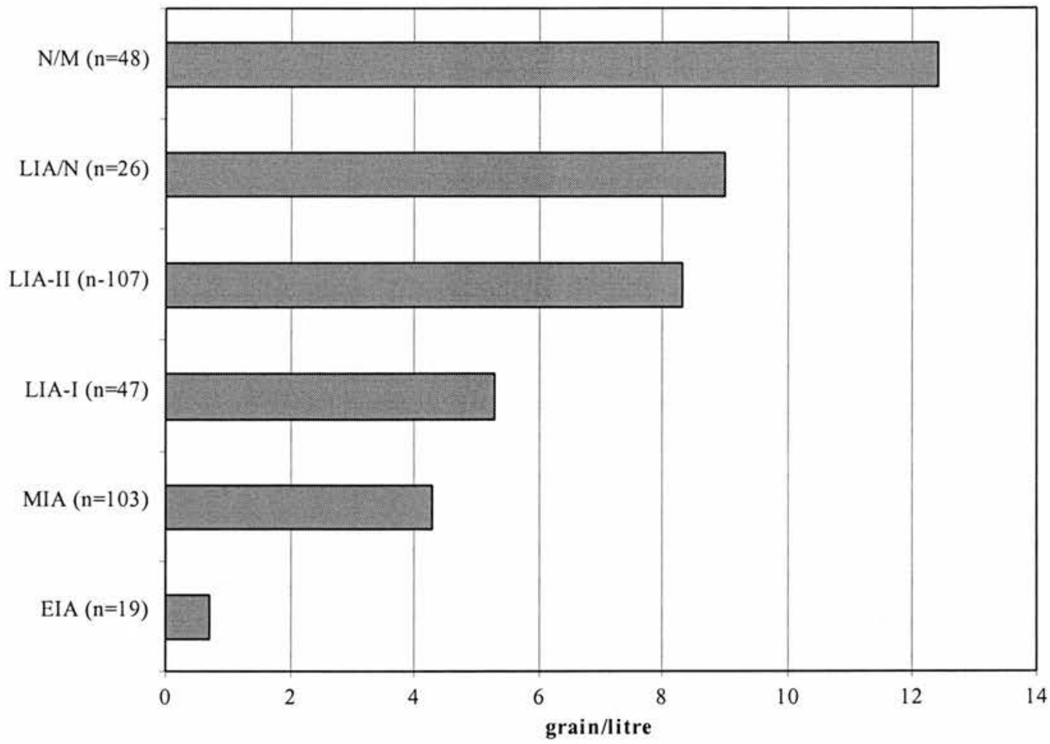


Figure 8.1: Grain concentration by period for domestic blocks in the Western Isles

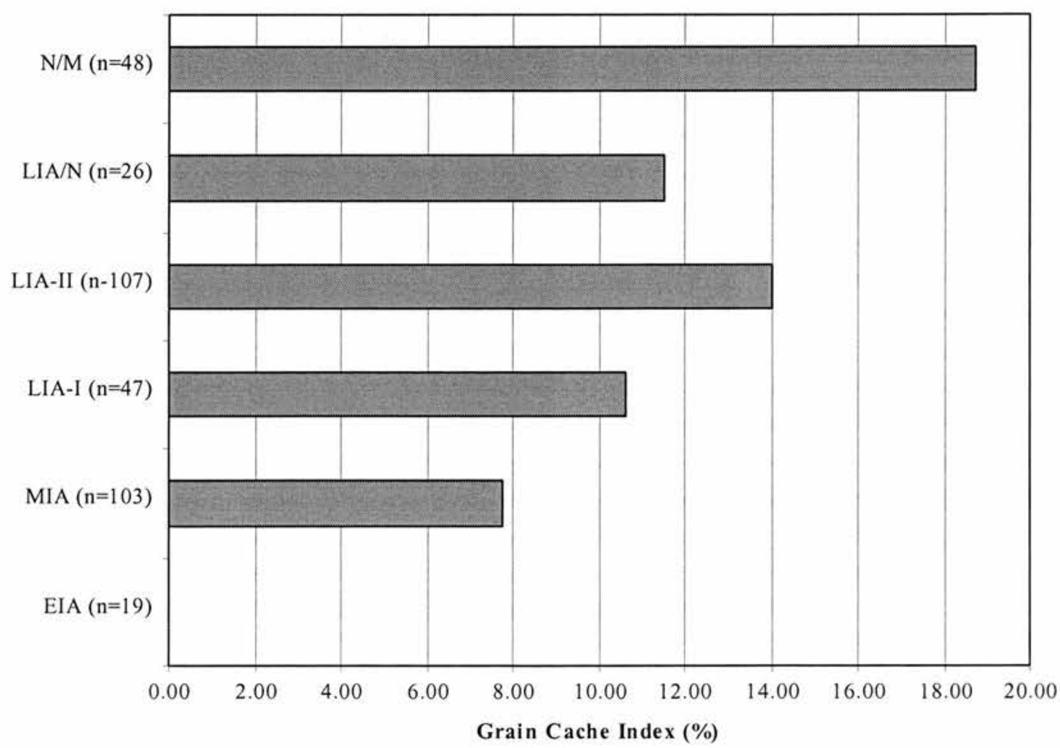


Figure 8.2: Grain Cache Index by period for domestic blocks in the Western Isles

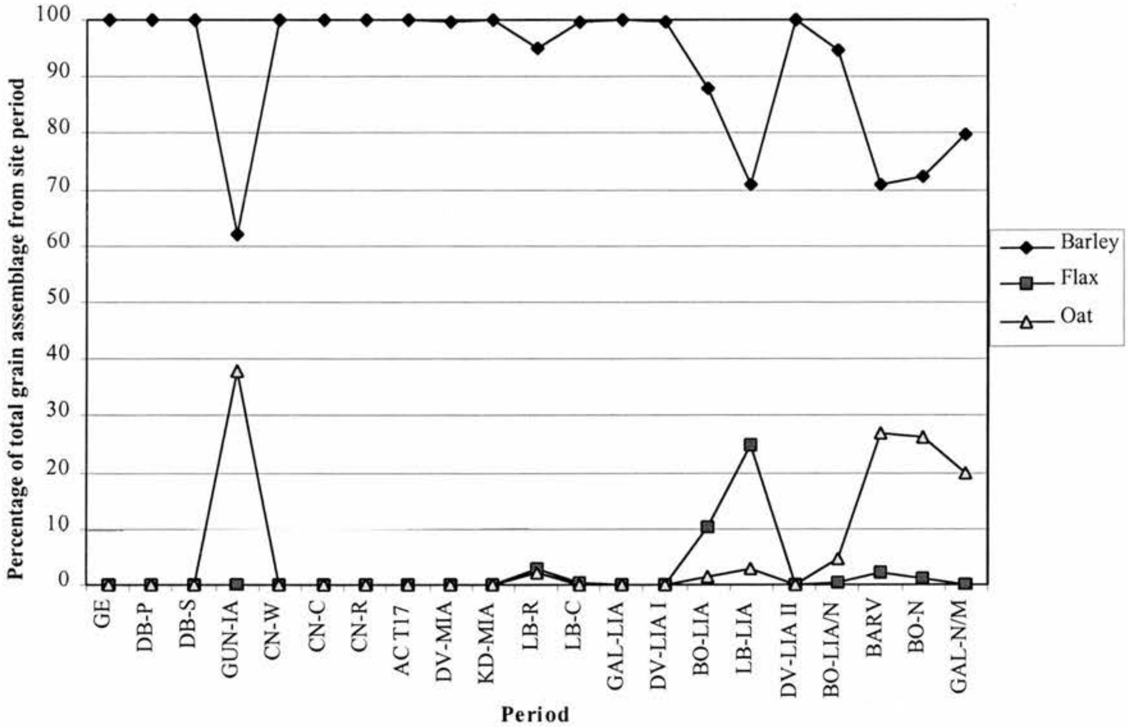


Figure 8.3: Proportions of identifiable cultivated genera from each domestic block in the Western Isles with at least 10 identifiable cultivated seeds/grain

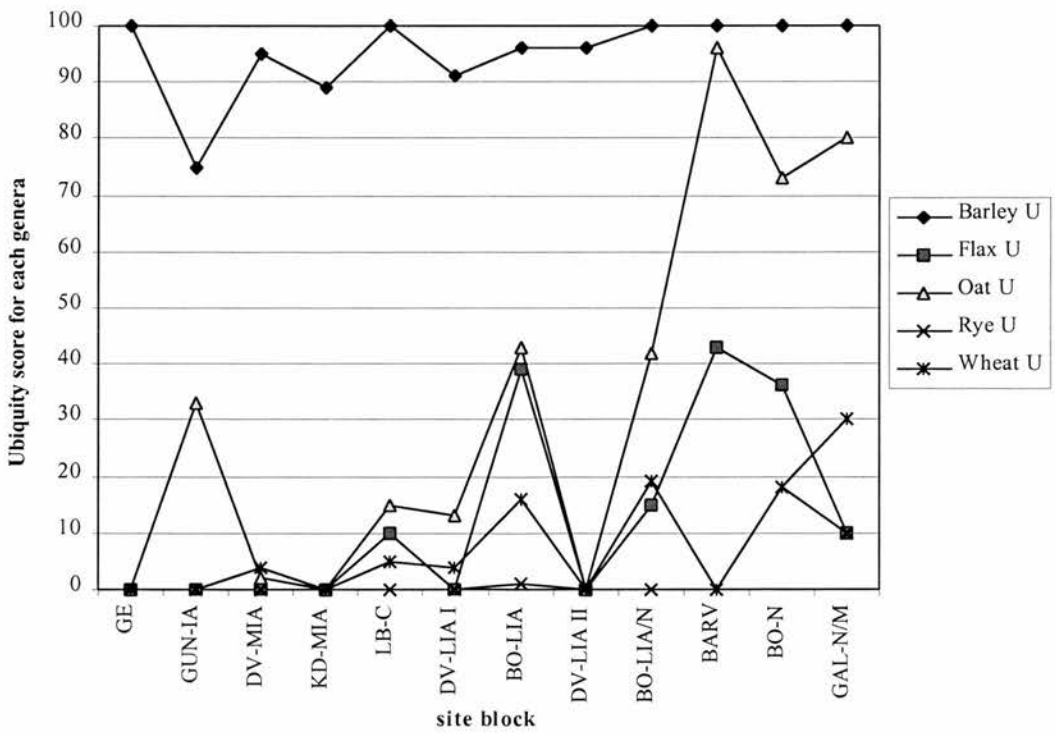


Figure 8.4: Ubiquity scores for each identifiable cultivated genera from each domestic block in the Western Isles with at least 10 samples

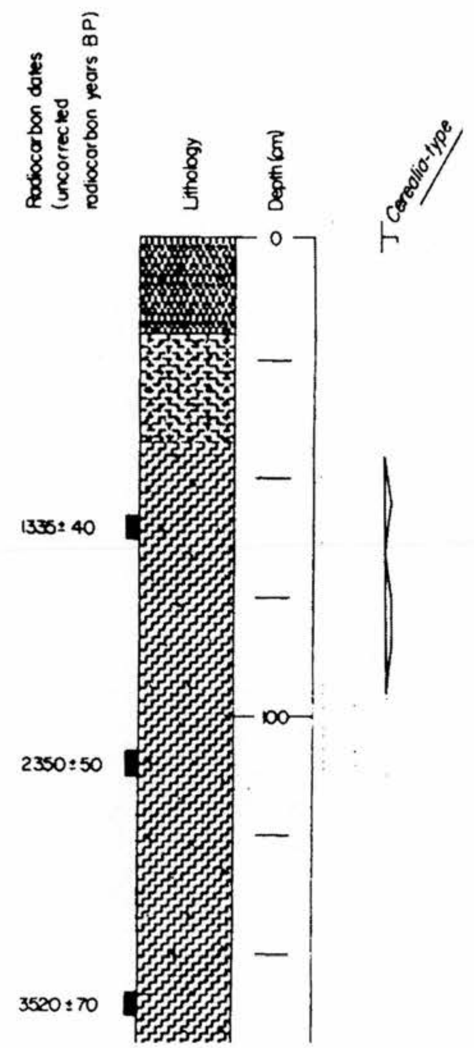


Figure 8.5: The first appearance of significant quantities of cereal pollen in the pollen spectrum from Little Loch Roag, West Lewis (modified after Birks & Madsen, 1979)

Tables

Sample			2	4	5	7
Context			3	3	1	3
Generic context type			OL	FL	OL	FL
Volume (litres)			28	28	28	28
Plant species	**Common name**	**Plant part**				
Charcoal						
Betula sp. roundwood	Birch	roundwood		1F(0.03)		
Corylus avellana L.	Hazel	nutshell fragment			1F(0.01)	
Grain						
Hordeum						
H. hulled	Hulled barley	caryopsis		3	1	2
H. cf. hulled	cf. Hulled barley	caryopsis		1		
H. hulled symmetric	Hulled barley straight	caryopsis				1
Avena sp.	Oat	caryopsis	5	8	3	14
Cereal indeterminate	Cereal indeterminate	caryopsis				2
Chaff		**Grain total**	5	12	4	19
Hordeum vulgare L.	Six-row barley	rachis internode			1	
Cereal/monocotyledon (>2 mm.)		culm base			1	1
Wild species		**Chaff total**	0	0	2	1
Stellaria media (L.) Villars	Common chickweed	seed				1
Spergula arvensis L.	Corn-spurrey	seed		1		
Rumex spp.	Dock	nutlet		1		
Viola sp.	Violet	seed	1			
Brassica/Sinapis spp.	Cabbage/Mustard	seed			2	
Euphorbia helioscopia L.	Sun spurge	seed	5	1		
Chrysanthemum segetum L.	Corn marigold	achene		4		
Poaceae (small) undiff.	Grass	caryopsis	1			
Poaceae (medium) undiff.	Grass	caryopsis			1	
Monocotyledon (<2 mm.)		culm base		4	1	
Indeterminate (>2 mm.)		rhizome	1			1
Indeterminate (<2 mm.)		rhizome		2	2	2
Indeterminate seed/fruit		seed/fruit	1			
		Wild total	9	13	6	4
Total QC			14	25	12	24
QC/litre			0.50	0.89	0.43	0.86
Grain (%)			35.7	48.0	33.3	79.2
Chaff (%)			0.0	0.0	16.7	4.2
Wild species (%)			64.3	52.0	50.0	16.7

Table 1.1: Carbonised plant macrofossils from Bereiro post-Medieval blackhouse

SITE	FEATURE	ENVIRONMENT	DIRECT DATING	CORRELATION	REFERENCES
Harris mountains (for example).	Glacial and periglacial erosion/ deposition features.	Local glaciation in upland areas.	None	Loch Lomond Readvance	Geikie 1878 von Weymarn 1974, 1979
Uig and Glen Valtos (for example).	Eskers, kames and glaciofluvial meltwater features.	Deglaciation	None	Late Devensian / post Glacial	Peacock 1984
Galson beach and Tolsta Head	Glacial till and lodgement till.	Glacial	Radiocarbon and amino acid dates from shell.	Late Devensian	Sutherland and Walker 1984
Tolsta Head	Peat layer	Interstadial - open landscape (flora of cool maritime).	Radiocarbon dating $27\ 333 \pm 240$ bp (SRR 87)	Mid Devensian	von Weymarn and Edwards 1973
Galson Beach	Raised gravel beach.	?	None	early Devensian (?)	Baden Powell and Elton 1937 von Weymarn 1974, 1979
Toa Galson	Solifluction deposit.	Periglacial	None	early Devensian (?)	Sutherland and Walker 1984
Toa Galson	Possible interglacial peat	Maritime grassland changing to acid heathland.	None	Ipswichian (??)	Sutherland and Walker 1984 Peacock 1984
North Lewis coastline	Till deposited on rock platform.	Glacial	None	pre Devensian / Wolstonian (??)	Sutherland and Walker 1984
North Lewis coastline	Formation of a raised rock platform and marine cliff with subsequent period of erosion.	?	None	pre Devensian / Wolstonian (??)	Godard 1965 McCann 1968 von Weymarn 1974

Table 2.1: Summary of Quaternary evidence in Lewis

Note: This table represents a stylised stratigraphy extrapolated from many sites, with the earliest event (the raised rock platform) at the base of the table. The question marks after some correlation entries signifies the degree of uncertainty of correlation; this becomes more marked with age.

Period	**Peat type**	**Inferred climate**	**Pollen zone**	**Approximate age (BP)**
Pre-Boreal	Hydrosere peat	Cool/dry	IV	10000–9500
Boreal	Humified peat and pine stumps	Warm/dry	V/VI	9500-7000
Atlantic	Unhumified peat	Warm/wet	VIIa	7000-5000
Sub-Boreal	Humified peat and pine stumps	Warm/dry	VIIb	5000-2500
Sub-Atlantic	Unhumified peat	Cool/wet	VIII	2500-present

Table 2.2: The Blytt-Sernander zonation of Holocene climate (after Roberts, 1989)

Site	Eilean Domhnuill	Bharpa Carinish	Geiriscleit	Allt Chrisal	Rosinish	Ceann nan Clachan	Baleshare	Hornish point	Kildonan III	Alt Chrisal T17	Dun Vulan	Barvas
Site type	Islet	Settlement	Funerary	Settlement	Field system	Funerary	Settlement	Wheelhouse	Wheelhouse	Wheelhouse	Settlement	Longhosue
Period	Neo	Neo	Neo	Neo/EBA	EBA	BA	MIA	MIA	MIA	MIA	MIA/LIA	Norse
No. of samples	43	23	10	9	Unknown	23	176	177	32	7	50	29
Sampling strategy	Judgement	Total	Judgement	Judgement	Judgement	Judgement	Total	Total	Judgement	Judgement	Total	Judgement
Cultivated plants			none									
Two-row barley												
Six-row barley	A	A		A		P	A	A	A	P	A	A
Naked barley	P	A		A	A	P			P		P	
Hulled barley	A	P		P	P	P	A	A	A	P	A	A
Emmer wheat		A			P			P			P	
Bread wheat	P											
Common vetch												P
Flax												P
Oat											P	A
Rye											P	
Gathered plants					not analysed		none	none	none	none		none
Bearberry	P											
Bilberry				P		P						
Bramble				P								
Cowberry				P								
Crab apple		P		P								
Crowberry											P	
Hazelnut	P	A	P	P							P	
Wild strawberry				P								
Charcoal					not analysed		not analysed	not analysed	not analysed	not analysed	wood only	
Alder	P			P							P	
Birch	A	A	A	A								P
Hazel	A	A	P	P		P					P	
Larch	P										A	
Ling heather	P		P	P		P						
Oak												
Pine	P		P	P							P	
Pomoideae		P		A								
Purging buckthorn											P	
Sloe type				P								
Spruce												P
Willow	P	P										

P = Present, A = Abundant

Table 2.3: Plant macrofossil assemblages from the Western Isles

Site	No. of samples processed	No. of samples following standardisation for macrofossils (% of total)	No. of samples following standardisation for charcoal (% of total)
An Dunan	111	13 (12%)	25 (23%)
Bostadh	298	118 (40%)	27 (9%)
Calanais kerb cairn	33	12 (36%)	14 (42%)
Cnip	44	8 (18%)	15 (34%)
Dun Bharabhat	15	3 (20%)	11 (73%)
Galson	20	12 (60%)	7 (35%)
Gob Eirer	44	18 (41%)	26 (59%)
Guinnerso	24	12 (50%)	15 (63%)
Loch na Beirgh	75	25 (33%)	29 (39%)
Total	664	221 (33%)	169 (25%)
Judgement samples			
Cnip	44	8 (18%)	15 (34%)
Dun Bharabhat	15	3 (20%)	11 (73%)
Loch na Beirgh	37	8 (22%)	13 (35%)
Total (% of total above)	96 (14%)	19 (9%)	39 (23%)

Table 3.1: Sample totals from all sites

Context (treatment)	Radish seed count in flot	Radish seed count in residue	Proportion in flot (%)	Overall recovery rate (%)
C.509 (dried)	95	3	96.9	98
C.559 (dried)	94	4	95.9	98
C.559 (dried)	96	1	99.0	97
C.553 (soaked)	50	47	51.5	97
C.559 (soaked)	49	49	50.0	98
C.559 (soaked)	51	46	52.6	97
C.553 (no treatment)	97	0	100.0	97
C.559 (no treatment)	96	1	99.0	97
C.559 (no treatment)	98	0	100.0	98

Table 3.2: Recovery efficiency of wet-sieving station (Recovery Test 1)

	4F	2F	1F	4R	2R	1R
Pottery (diagnostic)				*W*		
Pottery (undiagnostic)				*W*		
Worked mineral				*W*		
Small bones (diagnostic)	*C W*	*C*	*C*	*C W*	*C*	*C*
Large bones (diagnostic)	*C W*			*C W*		
Large bones (fragments)	*W*			*W*		
Fish bone	*C*	*C*	*C*	*C*	*C*	*C*
Otoliths	*C*	*C*	*C*	*C*	*C*	*C*
Marine mollusc	*C*	*C*	*C*	*C*	*C*	*C*
Marine mollusc (fragments)	*W*			*W*		
Terrestrial mollusc	*C*	*C*	*C*	*C*	*C*	*C*
Uncarbonised plant remains	*	*	*	*	*	*
Wood fragments	*C W*			*C*		
Charcoal	*C W*			*C*		
Cereal caryopsis	*C*	*C*	*C*	*C*	*C*	*C*
Rachis	*C*	*C*	*C*	*C*	*C*	*C*
Culm node	*C*	*C*	*C*	*C*	*C*	*C*
Culm base	*C*	*C*	*C*	*C*	*C*	*C*
Carbonised seeds	*C*	*C*	*C*	*C*	*C*	*C*
Nutshell (fragments)	*C W*			*C W*		
Amorphous plant material (burnt peat)	*W*			*W*		

Key: C = Count, W = Weigh, 4F/2F/1F = Flot fraction size, 4R/2R/1R = Residue fraction size

Table 3.3: Material classes sorted from samples

Site	Soil type and landscape setting	Soil moisture	Soil organic content (% mean)	Average flot recovery (% of total caryopses in flot)	Number of samples with greater than 10 caryopses
An Dunan	Friable sandy silt on islet in estuarine saltings	Damp	10.9	94.5	3
Bostadh	Light sand within machair	Dry	3.5	85.9	114
Galson	Light sand within machair	Dry	5.1	92.2	9
Gob Eirer	Heavy clayey silt on promontory stack	Wet	12.93	8.0	15
Guinnerso	Heavy sandy silt within moorland	Damp to wet	15.3	100	3
Loch na Beirgh	Seasonally to permanent waterlogged sandy silt within machair slack	Wet to waterlogged	11.7	82.2	37

3.4: Recovery efficiency of archaeobotanical material (Recovery Test 2)

Grain	Common name	Plant part
Hordeum sp.	barley grain	caryopsis
H. *distichon* var. *vulgare* L.	Two-row hulled barley grain	caryopsis
H. *vulgare* var. *vulgare* L. asymmetric	Six-row hulled barley twisted grain	caryopsis
H. *vulgare* var. *vulgare* L. symmetric	Six-row hulled barley straight grain	caryopsis
H. naked	naked barley grain	caryopsis
H. cf. naked	cf. naked barley grain	caryopsis
H. naked symmetric	naked barley straight grain	caryopsis
H. naked asymmetric	naked barley twisted grain	caryopsis
H. hulled	hulled barley grain	caryopsis
H. cf. hulled	cf. hulled barley grain	caryopsis
H. hulled symmetric	hulled barley straight grain	caryopsis
H. hulled asymmetric	hulled barley twisted grain	caryopsis
Triticum sp.	wheat grain	caryopsis
Avena sp.	oat grain	caryopsis
A. *sativa* L.	Cultivated oat grain	caryopsis
Secale cereale L.	Rye grain	caryopsis
Linum usitatissimum sp.	Flax seed	seed
Cereal indeterminate	cereal grain	caryopsis
Chaff		**Total grain**
Cereal indeterminate	cereal awn	awn fragment
Hordeum sp.	barley rachis	rachis internode
H. *distichon* var. *vulgare* L.	Two-row hulled barley rachis	rachis internode
H. cf. *distichon* var. *vulgare* L.	cf. Two-row barley rachis	rachis internode
H. *distichon* var. *vulgare* L.	Two-row hulled barley basal rachis	basal rachis
H. *distichon* var. *vulgare* L.	Two-row hulled barley sterile lateral spikelet	sterile lateral spikelets
H. *vulgare* var. *vulgare* L.	Six-row hulled barley rachis	rachis internode
H. *vulgare* var. *vulgare* L.	Six-row hulled barley basal rachis	basal rachis
H. *vulgare* L.	Six-row barley rachis	rachis internode
H. *vulgare* L.	Six-row barley basal rachis	basal rachis internode
H. cf. *vulgare* L.	cf. Six-row barley rachis	rachis internode
H. *distichon* L.	Two-row barley rachis	rachis internode
H. cf. *distichon* L.	cf. Two-row barley rachis	rachis internode
A. *sativa* L.	Cultivated oat floret base	floret base
Cereal/monocotyledon (>2 mm.)	cereal/monocotyledon culm node	culm node
Cereal/monocotyledon (>2 mm.)	cereal/monocotyledon culm base	culm base
Wild plants		
Pteridium aquilinium (L.) Kuhn	Bracken	leaf fragment
Juniperis communis L.	Common juniper	whole pericarp
Ranunculus spp.	buttercup	achene
Ranunculus acris L.	Meadow buttercup	achene
Ranunculus bulbosus L.	Bulbous buttercup	achene
Ranunculus cf. *bulbosus* L.	cf. Bulbous buttercup	achene
Ranunculus cf. *repens* L.	cf. Creeping buttercup	achene
Ranunculus repens L.	Creeping buttercup	achene
Fumaria officanalis L.	Common fumitory	fruit
Urtica dioica L.	Common nettle	fruit
Urtica urens L.	Small nettle	fruit
Betula sp.	birch	seed
Corylus avellana L.	Hazel	nutshell fragment
Chenopodium/Atriplex spp.	goosefoot/orache	seed
Chenopodium album L.	Fat-hen	seed
Atriplex spp.	oraches	seed
Atriplex hastata L.	Spear-leaved orache	seed
Montia fontana L.	Blinks	seed

Stellaria media (L.) Villars	Common chickweed	seed
Spergula arvensis L.	Corn-spurrey	seed
Persicaria lapathifolia (L.) Gray	Pale persicaria	nutlet
Persicaria maculosa Gray	Redshank	nutlet
Polygonum cf. *oxyspermum* (M. & B. ex Lb.)	Ray's Knotgrass	nutlet
Polygonum spp.	Knotgrasses	nutlet
Polygonum aviculare L.	Knotgrass	nutlet
Polygonum cf. *aviculare* L.	cf. Knotgrass	nutlet
Fallopia convolvulus L. A. Love	Black-bindweed	nutlet
Rumex spp.	docks	nutlet
Rumex acetosella L.	Sheep's sorrel	nutlet
Rumex acetosa L.	Common sorrel	nutlet
Rumex cf. *crispus* L.	cf. Curled dock	nutlet
Rumex crispus L.	Curled dock	nutlet
Hypericum pulchrum L.	Slender St. John's-wort	seed
Viola spp.	Violets	seed
Brassicaceae undiff.	cabbage family	capsule base
Brassicaceae undiff.	cabbage family	seed
Brassica/Sinapis spp.	cabbage/mustard	seed
Brassica cf. *rapa* L.	cf. Wild turnip	seed
Brassica rapa L.	Wild turnip	seed
Sinapis arvensis L.	Charlock	seed
Raphanus raphanistrum L.	Wild radish	fruit
Empetrum nigrum L.	Crowberry	fruit
Arctostaphylos uva-ursi (L.) Sprengel	Bearberry	fruit
Calluna vulgaris (L.) Hull.	Ling heather	capsule
Calluna vulgaris (L.) Hull.	Ling heather	leaf
Erica/Calluna spp.	heather	leaf fragment
Erica/Calluna spp.	heather	capsule
Erica tetralix L.	Cross-leaved heather	leaf fragment
Vaccinium myrtillus L.	Bilberry	seed
Vaccinium vitis-idaea L.	Cowberry	seed
Potentilla spp.	cinquefoils	seed
Potentilla erecta (L.) Raeusch	Tormentil	seed
Sorbus aucuparia L.	Rowan	seed
Sorbus sp.	whitebeam genus	seed
cf. *Vicia/Lathyrus* spp.	vetch/pea	seed
Vicia/Lathyrus spp.	vetch/pea	seed
Vicia sativa L.	Common vetch	seed
Trifolium repens L.	Clover	seed
Trifolium spp.	clovers	seed
Stachys spp.	woundworts	fruit
Stachys cf. *palustris* L.	cf. Marsh woundwort	fruit
Galeopsis tetrahit L.	Common hemp-nettle	nutlet
Ajuga reptans L.	Bugle	seed
Plantago lanceolata L.	Ribwort plantain	seed
Galium aparine L.	Cleaver	nutlet
Chrysanthemum segetum L.	Corn marigold	achene
Cyperaceae undiff.	sedge family	seed
Eleocharis palustris L	Common spike-rush	nutlet
Carex spp. (biconvex)	sedge	nutlet
Carex spp. (trigonous)	sedge	nutlet
Poaceae undiff.	grasses	spikelet
Poaceae undiff. (small)	grasses	caryopsis
Poaceae undiff. (medium)	grasses	floret/spikelet
Poaceae undiff. (medium)	grasses	caryopsis

Poaceae undiff. (large)	grasses	caryopsis
Poa cf. *annua* L.	cf. Annual meadow-grass	caryopsis
Danthonia decumbens L.	Heath-grass	caryopsis
Cereal/monocotyledon (<2 mm.)	cereal/monocotyledon culm node	culm node
Cereal/monocotyledon (<2 mm.)	cereal/monocotyledon culm base	culm base
Indeterminate (>2 mm.)	indeterminate rhizome	rhizome
Indeterminate (trigonous)	indeterminate trigonous seed/fruit	seed/fruit
Indeterminate pericarp fragment	indeterminate pericarp fragment	pericarp fragment
Indeterminate seed/fruit	indeterminate seed/fruit	seed/fruit
Lichen (foliose) fragment	lichen (foliose) leaf fragment	leaf fragment
Moss fragments (carbonised)	moss leaf fragment (carbonised)	leaf fragment
Seaweed	seaweed fragment	fragment
Cenococcum geophylum Fr. (carbonised)	fungus	fungal sclerotia

Table 3.5a: Archaeobotanical material recovered from the overall study: carbonised plant macrofossils

Botanical name	**Common name**
Deciduous roundwood	
Alnus sp. roundwood	alder
Bark roundwood	bark
Betula sp. roundwood	birch
Calluna vulgaris (L.) Hull. roundwood	Ling heather
Corylus sp. roundwood	hazel
Pomoideae undiff. Roundwood	pomaceous fruits
Prunus sp. roundwood	*Prunus* genus
Salix sp. roundwood	willow
Deciduous timber	
Alnus sp.	alder
Betula sp.	birch
Corylus sp.	hazel
Fraxinus sp.	ash
Pomoideae undiff.	pomaceous fruits
Prunus sp.	*Prunus* genus
Quercus sp.	oak
Salix sp.	willow
Coniferous roundwood	
Juniperis communis L. roundwood	Juniper
Pinus sp. roundwood	pine
Pinus sylvestris L. roundwood	Scots Pine
Coniferous timber	
Abies sp.	fir
Coniferae undiff.	conifer
Larix sp.	larch
Picea sp.	spruce
Pinus sp.	pine
Pinus sp. bark	pine bark
Pseudotsoga taxifolia L.	Douglas fir
Indeterminate	
Indet. roundwood/rootwood	indeterminate
Indet.	indeterminate
Miscellaneous	
Bark fragment	bark
Seaweed fragment	seaweed

Table 3.5b: Archaeobotanical material recovered from the overall study: charcoal

Cereal type	**Criteria**
Hordeum sp. caryopsis	Shallow ventral groove with no dorsal ridge. Cross-section morphology indistinct.
H. naked caryopsis	Cross-section rounded, with general rounded appearance and horizontal lines visible on dorsal and ventral sides.
H. cf. naked caryopsis	Cross-section rounded, with general rounded appearance but horizontal lines not visible on dorsal and ventral sides.
H. naked symmetric caryopsis	Cross-section rounded, with general rounded appearance and horizontal lines visible on dorsal and ventral sides (straight grain).
H. naked asymmetric Caryopsis	Cross-section rounded, with general rounded appearance and horizontal lines visible on dorsal and ventral sides (twisted grain).
H. hulled caryopsis	Hulled material attached to grain or cross-section clearly angular, with general angular appearance.
H. cf. hulled caryopsis	Cross-section and general appearance quite angular but no hulled material attached.
H. hulled symmetric caryopsis	Hulled material attached to grain or cross-section clearly angular, with general angular appearance (straight grain).
H. hulled asymmetric caryopsis	Hulled material attached to grain or cross-section clearly angular, with general angular appearance (twisted grain).
Triticum sp. caryopsis	Deep ventral groove with pronounced dorsal ridge (further criteria for each species).
Avena sp. caryopsis	Long and thin with rounded cross-section.
Secale cereale L. caryopsis	Long and thin with pronounced dorsal ridge.
Cereal indet. Caryopsis	No identification criteria surviving (generally heavily fragmented and vesiculated).
H. *vulgare* L. rachis internode	Clearly broadening shoulder with large disarticulation scar.
H. *distichon* L. rachis internode	Generally narrow straightened profile with little broadening at the shoulder and relatively narrow disarticulation scar.

Table 3.6: Identification criteria for cereal remains

Generic context type	Description	Abbreviation	Analyse?
Ash spread	Ash rich context within occupation levels.	AS	Y
Cell/feature fill	Mixed material filling a structural cell or feature.	CFF	No. Mixed material from unknown period.
Clay (natural)	Natural clay within site, presumably as material for pot manufacture.	CL	No. Little archaeobotanical relevance.
Floor level	Distinct occupation level that appears during excavation to be contemporary with main structural features.	FL	Y
Foundation deposit	Mixed layer that appears to be deliberately laid down as a foundation for structural features.	FD	No. Mixed material from unknown period.
Hearth material	Ash or burnt material found within, or immediately adjacent to an in situ hearth.	HM	Y
Midden	Mixed material, rich in 'domestic' debris, that appears during excavation to be contemporary with main structural features.	M	Y
Negative feature fill	Negative feature fill (pit fill, ditch fill, post-hole) sealed by phased material.	NFF	Y
Occupation level	Generic context with admixture of archaeological material that appears during excavation to be contemporary with main structural features.	OL	Y
Old ground surface	Relic soil horizon.	OGS	No. Possible period mixing by redeposition and bioturbation.
Subsoil	Subsoil or parent material	SS	No. Little archaeobotanical relevance.
Rubble	Stone rich deposit containing clear evidence of collapsed structural features.	R	No. Little possibility of coherent material, possible period mixing and very difficult to wet-seive.
Topsoil or post-deposition soil formation	Topsoil or post-deposition soil formation	TS	No. Post-deposition soil formation will cause excessive mixing and possible bioturbation.
Wall fill	Mixed material used to fill or support wall material.	WF	No. Mixed material from unknown period.
Wind blown sand	'Natural' sand levels.	WBS	No. Possible period mixing by redeposition and bioturbation.

Table 3.7: Generic context types for overall study

κ_{fd}	Measurement range (%)	Domain state
Low	< 2.0	Virtually no SPM grains, probably < 10%
Medium	2.0 – 10.0	Admixture of SPM and coarser SSD and MD grains
High	10.0 – 14.0	Virtually all SPM grains
Very high	> 14.0	Erroneous measurement, anisotropy, weak sample or metal contamination.

Table 3.8: Domain state and κ_{fd} (Source: Dearing, 1994)

Provenance	Context description	Uncalibrated date	δ^{13} C
CC-3, C.121, C^{14}S.A	Ash spread in body of cairn (AMS; barley caryopsis)	3418±38 (OxA-9903)	-24.1
CC-3, C.121, C^{14}S.B	Ash spread in body of cairn (AMS; barley caryopsis)	3310±45 (OxA-9865)	-22.5
CC-3, C.129, C^{14}S.A	Ash spread in body of cairn (AMS; barley caryopsis)	3325±40 (OxA-9866)	-23.3
CC-3, C.129, C^{14}S.B	Ash spread in body of cairn (AMS; barley caryopsis)	4225±85 (OxA-9931)	-22.6
CC-3, C.135, C^{14}S.A	Ash spread in body of cairn (AMS; barley caryopsis)	3295±40 (OxA-9867)	-23.4
CC-3, C.135, C^{14}S.B	Ash spread in body of cairn (AMS; barley caryopsis)	3385±45 (OxA-9868)	-24.5
CC-3, C.181, C^{14}S.A	Ash spread in body of cairn (AMS; barley caryopsis)	3355±45 (OxA-9869)	-21.5
CC-3, C.181, C^{14}S.B	Ash spread in body of cairn (AMS; barley caryopsis)	3433±39 (OxA-9870)	-22.2
GE, S.23, C.47, C^{14}S.A	Fill of possible cultivation furrow underlying pathway (AMS; barley caryopsis)	2470±50 (OxA-8459)	-24.3
GE, S.23, C.47, C^{14}S.B	Fill of possible cultivation furrow underlying pathway (AMS; barley caryopsis)	2465±50 (OxA-8573)	-24.4
GE, S.12, C.28, C^{14}S.A	Occupation level in circular features (AMS; barley caryopsis)	2580±50 (OxA-8466)	-23.7
GE, S.12, C.28, C^{14}S.B	Occupation level in circular features (AMS; barley caryopsis)	2660±50 (OxA-8467)	-23.8
DB-P, C.158	Pre-roundhouse occupation level (bulk; uncarbonised wood)	2550±50 (GU-2436)	-23.5
DB-S, C.169, C^{14}S.A	Secondary occupation destruction layer (bulk; charred timber)	2010±50 (GU-2434)	-25.9
DB-S, C.169, C^{14}S.B	Secondary occupation destruction layer (bulk; charred timber)	2100±50 (GU-2435)	-24.2
AD-IA, S.102, C.153	Occupation level of underlying building (AMS; barley caryopsis)	2250±35 (OxA-8480)	-23.8
AD-IA, S.47, C.67, C^{14}S.A	Ash spread within floor level of underlying building (AMS; barley caryopsis)	1985±45 (OxA-8477)	-24.6
AD-IA, S.47, C.67, C^{14}S.B	Ash spread within floor level of underlying building (AMS; hazel nutshell)	2215±40 (OxA-8478)	-22.8
AD-IA, S.110, C.152, C^{14}S.A	Hearth material of underlying building (autoduplicate AMS; barley caryopsis)	2035±50 (OxA-8576)	-24.6
AD-IA, S.110, C.152, C^{14}S.B	Hearth material of underlying building (autoduplicate AMS; barley caryopsis)	2230±50 (OxA-8577)	-25.1
AD-IA, S.104, C.128, C^{14}S.A	Hearth material of underlying building (AMS; barley caryopsis)	2145±40 (OxA-8479)	-23.4
AD-IA, S.104, C.128, C^{14}S.B	Hearth material of underlying building (AMS; barley caryopsis)	2165±40 (OxA-8613)	-21.7
AD-IA, S.109, C.151	Hearth material of underlying building (AMS; barley caryopsis)	2155±45 (OxA-8575)	-24.6
CN-W, C.276, C^{14}S.A	Wheelhouse occupation level (bulk; cattle bone)	2600±150 (GU-2756)	-22.9
CN-W, C.276, C^{14}S.B	Wheelhouse occupation level (bulk; cattle and deer bone)	1990±50 (GU-2755)	-22.3
CN-W, C.131, C^{14}S.A	Wheelhouse occupation level (bulk; cattle bone)	2280±140 (GU-2758)	-22.5
CN-W, C.131, C^{14}S.B	Wheelhouse occupation level (bulk; cattle bone)	1960±90 (GU-2757)	-21.6
CN-W, C.116	Ritual deposit behind wheelhouse wall (bulk; cattle bone)	2370±130 (GU-2754)	-21.6
CN-C, C.265	Secondary occupation level in wheelhouse (bulk; cattle bone)	1920±60 (GU-2749)	-21.4
CN-C, C.266, C^{14}S.A	Occupation level in cellular building (bulk; cattle and deer bone)	1930±90 (GU-2746)	-23.8
CN-C, C.266, C^{14}S.B	Occupation level in cellular building (bulk; cattle and deer bone)	1890±50 (GU-2748)	-22.6
CN-C, C.72	Wooden handle of spade-shoe in secondary infill of wheelhouse (AMS; indet. wood)	1910±45 (AA-29767)	-25.6
CN-C, C.204, C^{14}S.A	Secondary occupation level in wheelhouse (bulk; cattle and deer bone)	1900±50 (GU-2752)	-21.1
CN-C, C.204, C^{14}S.B	Secondary occupation level in wheelhouse (bulk; cattle and deer bone)	1850±50 (GU-2751)	-22.5
CN-C, C.223	Occupation level in cellular building (bulk; cattle and deer bone)	1890±50 (GU-2747)	-21.9
CN-R, C.113	Floor level in rectilinear building (bulk; cattle and deer bone)	1940±70 (GU-2742)	-22.8
CN-R, C.109	Floor level in rectilinear building (bulk; cattle, pig and deer bone)	1930±50 (GU-2743)	-22.3
CN-R, C.83, C^{14}S.A	Floor level in rectilinear building (bulk; cattle bone)	1870±70 (GU-2745)	-22.7
CN-R, C.83, C^{14}S.B	Floor level in rectilinear building (bulk; cattle bone)	1770±80 (GU-2744)	-23.7
CN-R, C.42	Floor level in rectilinear building (bulk; cattle and deer bone)	1810±190 (GU-2741)	-22.5
LB-R, C.153	Floor level in gallery accessed during roundhouse phase (bulk; hazel charcoal)	1760±50 (GU-4923)	-26.6

LB-C, C.556, C^{14}S.A	Foundation level for Primary Cellular Phase (bulk; Scot's Pine charcoal)	1700±50 (GU-4927)	-25.0
LB-C, C.426, C^{14}S.A	Souterrain floor level (bulked AMS; Pomoideae undiff. charcoal)	1650±55 (AA-23724/ GU-4925)	-31.1
LB-C, C.438, C^{14}S.A	Hearth material from Cell 3 (bulked AMS: barley caryopses)	1595±60 (AA-23723/ GU-4924)	-26.6
LB-C, C.454	Hearth material from Final Cellular Phase (bulk; Pomoideae undiff. charcoal)	1580±60 (GU-4926)	-26.8
GAL-LIA, S.6, C.301	Floor level in cellular building (AMS; barley caryopsis)	1720±35 (AA-43455/ GU-9458)	-22.1
GAL-LIA, S.60, C.401, C^{14}S.A	Floor level in ventral building (AMS; barley caryopsis)	1720±40 (AA-43462/ GU-9468)	-21.2
GAL-LIA, S.60, C.401, C^{14}S.B	Floor level in ventral building (AMS; barley caryopsis)	1675±35 (AA-43463/ GU-9469)	-23.6
GAL-LIA, S.59, C.400	Hearth material in secondary occupation of ventral building (AMS; barley caryopsis)	1500±40 (AA-43461/ GU-9467)	-23.0
GAL-N/M, S.55, C.114, C^{14}S.A	Midden in upper level (AMS; barley caryopsis)	1070±35 (AA-43459/ GU-9464)	-23.2
GAL-N/M, S.55, C.114, C^{14}S.B	Midden in upper level (AMS; barley caryopsis)	1005±35 (AA-43460/ GU-9465)	-23.5
GAL-N/M, S.2, C.165, C^{14}S.A	Midden, revetted into by Structure B (AMS; barley caryopsis)	1030±40 (AA-43453/ GU-9456)	-23.6
GAL-N/M, S.2, C.165, C^{14}S.B	Midden, revetted into by Structure B (AMS; barley caryopsis)	1095±45 (AA-43454/ GU-9457)	-23.6
GAL-N/M, S.10, C.205, C^{14}S.A	Floor level of Structure B (AMS; barley caryopsis)	925±35 (AA-43456/ GU-9460)	-22.3
GAL-N/M, S.10, C. 205, C^{14}S.B	Floor level of Structure B (AMS; barley caryopsis)	920±35 (AA-43457 GU-9461)	-22.8
GAL-N/M, S.50, C.112a	Floor level in structure in upper level (AMS; barley caryopsis)	875±55 (AA-43458/ GU-9462)	-24.8
BO-LIA, S.261, C.714, C^{14}S.A	Ash spread in House 1, Phase V (AMS; barley caryopsis)	1195±45 (AA46094/GU-9653)	-23.9
BO-LIA, S.261, C.714, C^{14}S.B	Ash spread in House 1, Phase V (AMS; barley caryopsis)	1200±45 (AA-46095/GU-9654)	-24.2
BO-LIA, S.277, C.574, C^{14}S.A	Hearth material from House 2, Phase III (AMS; barley caryopsis)	1115±40 (AA-46098/GU-9657)	-23.2
BO-LIA, S.277, C.574, C^{14}S.C	Hearth material from House 2, Phase III (AMS; barley caryopsis)	1110±40 (AA-46099/GU-9658)	-23.8
BO-LIA, S.154, C.234, C^{14}S.A	Floor level of Structure G, Phase IV (AMS; barley caryopsis)	1220±40 (AA-46107/GU-9669)	-23.2
BO-LIA, S.154, C.234, C^{14}S.B	Floor level of Structure G, Phase IV (AMS; barley caryopsis)	1150±40 (AA-46079/GU-9637)	-22.5
BO-LIA, S.290, C.863, C^{14}S.B	Hearth material from Structure H, Phase III (AMS; barley caryopsis)	1145±45 (AA-46012/GU-9661)	-24
BO-LIA, S.290, C.863, C^{14}S.C	Hearth material from Structure H, Phase III (AMS; barley caryopsis)	1240±40 (AA-46103/GU-9662)	-23.1
BO-LIA, S.130, C.248, C^{14}S.A	Midden from Structure H, Phase XII (AMS; barley caryopsis)	1160±45 (AA-46087/GU-9645)	-22.2
BO-LIA, S.130, C.248, C^{14}S.C	Midden from Structure H, Phase XII (AMS; barley caryopsis)	1225±45 (AA-46088/GU-9646)	-22.2
BO-LIA, S.147, C.165	Floor level of Structure J, Phase IV (AMS; barley caryopsis)	1270±45 (AA-46096/GU-9655)	-23.6
BO-LIA, S.148, C.165	Floor level of Structure J, Phase IV (AMS; barley caryopsis)	1275±40 (AA-46097/GU-9656)	-24.6
BO-LIA, S.136, C.148	Floor level of Structure J, Phase VI (AMS; barley caryopsis)	1205±45 (AA-46089/GU-9647)	-23.1
BO-LIA, S.323, C.885/6	Pit fill from Structure L, Phase III (AMS; barley caryopsis)	1215±40 (AA-46104/GU-9666)	-23.4
BO-LIA, S.287, C.362, C^{14}S.A	Hearth material from Structure L, Phase IV (AMS; barley caryopsis)	1220±45 (AA-46100/GU-9659)	-23.2
BO-LIA, S.287, C.362, C^{14}S.B	Hearth material from Structure L, Phase IV (AMS; barley caryopsis)	1175±40 (AA-46101/GU-9660)	-25.3
BO-LIA, S.341, C.315	Floor level of Structure L, Phase V (AMS; barley caryopsis)	1185±40 (AA-46015/GU-9667)	-22.8
BO-LIA/N, S.258, C.707, C^{14}S.C	Midden from House 1, Phase VII (AMS; barley caryopsis)	1225±45 (AA-46092/GU-9651)	-22.7
BO-LIA/N, S.258, C.707, C^{14}S.D	Midden from House 1, Phase VII (AMS; barley caryopsis)	1195±45 (AA-46093/GU-9652)	-23.4
BO-LIA/N, S.140, C.112, C^{14}S.A	Midden from House 1, Phase VIII (AMS; barley caryopsis)	1145±45 (AA-46080/GU-9638)	-22.8
BO-LIA/N, S.140, C.112, C^{14}S.C	Midden from House 1, Phase VIII (AMS; barley caryopsis)	1190±40 (AA-46081/GU-9639)	-22.8

BO-LIA/N, S.242, C.33, C^{14}S.C	Ash spread from House 2, Phase VII (AMS; barley caryopsis)	1150±40 (AA-46090/GU-9649)	-25
BO-LIA/N, S.242, C.33, C^{14}S.D	Ash spread from House 2, Phase VII (AMS; barley caryopsis)	1195±50 (AA-46091/GU-9650)	-24.6
BO-N, S.26, C.53, C^{14}S.D	Norse midden (AMS; barley caryopsis)	1200±45 (AA-46082/GU-9640)	-23.3
BO-N, S.26, C.53, C^{14}S.E	Norse midden (AMS; barley caryopsis)	1100±45 (AA-46083/GU-9641)	-23.8
BO-N, S.26, C.53, C^{14}S.F	Norse midden (AMS; barley caryopsis)	1145±40 (AA-46084/GU-9642)	-23.9
BO-N, S.8, C.20, C^{14}S.A	Floor level in Structure A (AMS; barley caryopsis)	1180±45 (AA-46085/GU-9643)	-23.4
BO-N, S.8, C.20, C^{14}S.B	Floor level in Structure A (AMS; barley caryopsis)	1125±45 (AA-46086/GU-9644)	-23.8
AD-M, S.14, C.30, C^{14}S.A	Floor level of secondary building (AMS; rhizome fragment)	710±55 (OxA-8461)	-26.1
AD-M, S.14, C.30, C^{14}S.B	Floor level of secondary building (AMS; birch roundwood charcoal)	865±40 (OxA-8476)	-26.3
AD-M, S.5, C.5, C^{14}S.A	Cell fill of secondary building (AMS; barley caryopsis)	520±50 (OxA-8460)	-26.9
AD-M, S.5, C.5, C^{14}S.B	Cell fill of secondary building (AMS; barley caryopsis)	65±45 (OxA-8574)	-24.4

Table 4.1: Radiocarbon dates from archaeological sites

Block	AS	CFF	CL	DL	FD	FL	HM	M	NFF	OGS	OL	R	SS	TS	WBS	WF	Total
AD-IA	14	23	7			3	19		6				1	5		13	91
AD-M	1	5					1				1						8
AD-U	2	6				2								1		1	12
BO-E						2		1	5								8
BO-LIA	7	4				18	15	12	54	1	23	2			6	12	154
BO-LIA/N	4	31				3	1	15			8	1			5	3	71
BO-N						1		14							2		17
BO-U		20						3	1	1					6	17	48
CC-1									11								11
CC-2									1	3							4
CC-3	10								4								14
CC-4									2								2
CC-U									2								2
CN-W	5	4				2			1		1						13
CN-C	2	3			2	2	1	1			5					1	17
CN-R		5	1			4			2						1		13
CN-U								1									1
DB-P											1						1
DB-M											3						3
DB-S		2		6			3										11
GAL-LIA	1					3											4
GAL-N/M	3	1				3	1	7		1							16
GE	3					5			4		18	1	4	6		3	44
GUN-IA	6					11	5				2						24
LB-PR		2															2
LB-R		3			1			1		1						1	7
LB-C		10			3	6	10	4	3	3		3				3	45
LB-I									4								4
LB-LIA		7				1	1	1	1			1					12
LB-U		5															5
Totals	**58**	**131**	**8**	**6**	**6**	**66**	**57**	**60**	**101**	**10**	**62**	**8**	**5**	**12**	**20**	**54**	**664**

Table 4.2: Bulk sample breakdown prior to standardisation by block and generic context type (see Table 3.7 for abbreviations for generic context types)

Block	χ analysis	k_{fd} analysis	AS	CFF	CL	FD	FL	HM	M	NFF	OGS	OL	R	SS	TS	WBS	WF	Total
AD-IA	104	104	17	26	7	1	4	19		9				1	5		15	104
AD-M	8	8	1	5				1				1						8
AD-U	14	14	3	7			2								1		1	14
BO-E	5	0					2		1	2								5
BO-LIA	90	10	4	4			10	8	9	21		16	2			7	9	90
BO-LIA/N	60	1	4	30			2		9			6	1			5	3	60
BO-N	19	0					1		15		1					2		19
BO-U	48	0		19					3	1	1					5	19	48
CC-1	18	18								18								18
CC-2	9	9								2	7							9
CC-3	16	16	10							6								16
CC-4	3	3								3								3
CC-U	3	3								3								3
CN-W	7	7	3	2			2											7
CN-C	16	16	2	3		2	2	1	1			4					1	16
CN-R	13	13		5	1		4			2						1		13
CN-U	1	1							1									1
DB-P	2	2								1		1						2
DB-M	7	7										7						7
DB-S	10	10		2	2			5									1	10
GAL-LIA	4	4	1				3											4
GAL-N/M	20	20	3	1			3	1	7		1					4		20
GE	49	49	3				5			5		19	2	4	7		4	49
GUN-IA	24	24	6				11	5				2						24
LB-PR	2	2		2														2
LB-R	6	6		3		1			1		1							6
LB-C	29	29		5		2	2	7	4	1	3		2				3	29
LB-I	4	4								4								4
LB-LIA	11	11		7			1		1	1			1					11
LB-U	3	3		3														3
Totals	**605**	**394**	**57**	**124**	**10**	**6**	**54**	**47**	**52**	**79**	**14**	**56**	**8**	**5**	**13**	**24**	**56**	**605**

Table 4.3: Routine sample breakdown for mineral magnetic analysis by block and generic context type (see Table 3.7 for abbreviations for generic context types)

	Sample total	Contexts (#)							
Block	**macro analysis**	**AS**	**CON**	**FL**	**HM**	**M**	**NFF**	**OL**	**Total**
AD-IA	10	6			4				10
AD-M	3	2						1	3
BO-E	1						1		1
BO-LIA	80	5		12	15	10	25	13	80
BO-LIA/N	26	3		2	1	14		6	26
BO-N	11			1		10			11
CC-3	12	12							12
CN-W	3	1		1				1	3
CN-C	1			1					1
CN-R	4			3			1		4
DB-P	1							1	1
DB-M	1							1	1
DB-S	1		1						1
GAL-LIA	2	1		1					2
GAL-N/M	10	1		2	1	6			10
GE	18	1		3			2	12	18
GUN-IA	12	3		5	4				12
LB-R	1					1			1
LB-C	20			5	10	3	2		20
LB-LIA	4			1	1	1	1		4
Totals	**221**	**35**	**1**	**37**	**36**	**45**	**32**	**35**	**221**
%		**15.8**	**0.5**	**16.7**	**16.3**	**20.4**	**14.5**	**15.8**	**100.0**

Table 4.4: Bulk sample breakdown following standardisation by block and generic context type (see Table 3.7 for abbreviations for generic context types)

Block	Sample	Context	Context type	Volume (l)	Soil (g.)	κ_{hf}	κ_{lf}	χ ($\mu m^3 k g^{-1}$)	κ_{fd} (%)	QC/ litre	Charcoal frag / litre	Charcoal g. / litre
AD-IA	1	12	TS	28	8.21	163	179.5	2.19	9.19	0.21	0.11	0.02
AD-IA	2	3	CFF	28	9.73	55.5	62	0.64	10.48	0.00	0.07	0.00
AD-IA	3	3	CFF	28	6	23	23.5	0.39	2.13	0.00	0.00	0.00
AD-IA	4	2	CFF	28	8.63	211.5	233.5	2.71	9.42	0.00	0.00	0.00
AD-M	5	5	OL	28	8.86	65.5	74	0.84	11.49	0.86	0.00	0.00
AD-M	6	18	CFF	28	5.1	41.5	43	0.84	3.49	0.11	0.04	0.00
AD-U	7	7	CFF	28	4.6	38.5	40.5	0.88	4.94	n/a	n/a	n/a
AD-IA	8	21	CFF	14	5.7	15	16	0.28	6.25	0.14	0.00	0.00
AD-M	9	20	AS	28	8.41	553.5	607	7.22	8.81	2.50	0.71	0.03
AD-U	10	23	CFF	42	7.6	35.5	37	0.49	4.05	0.02	0.00	0.00
AD-IA	11	25	CFF	28	6.9	16.5	17	0.25	2.94	0.00	0.00	0.00
AD-IA	12	22	HM	28	9.29	897.5	964.5	10.38	6.95	0.21	0.25	0.01
AD-IA	13	25	CFF	28	5.8	22.5	23	0.40	2.17	0.00	0.04	0.00
AD-M	14	30	CFF	28	9.27	71.5	78.5	0.85	8.92	0.11	0.00	0.00
AD-IA	15	31	WF	28	6	26.5	28	0.47	5.36	0.07	0.04	0.00
AD-U	16	16	TS	28	8.77	100	112.5	1.28	11.11	0.07	0.00	0.00
AD-IA	17	32	CFF	28	6.3	38	39	0.62	2.56	n/a	n/a	n/a
AD-IA	18	34	WF	28	5.1	508.5	535	10.49	4.95	n/a	n/a	n/a
AD-IA	19	35	WF	28	7.97	1358	1455	18.26	6.67	n/a	n/a	n/a
AD-U	20	40	CFF	1	9.91	65	71	0.72	8.45	0.00	6.00	0.17
AD-IA	21	36	WF	14	6.2	22	23	0.37	4.35	0.00	0.00	0.00
AD-IA	22	37	CFF	14	5.4	21	22	0.41	4.55	n/a	n/a	n/a
AD-IA	23	41	CFF	14	5.8	20.5	21	0.36	2.38	0.00	0.00	0.00
AD-M	24	43	CFF	28	5.1	28	29	0.57	3.45	0.04	0.00	0.00
AD-IA	25	29	HM	49	8.53	1478	1576	18.48	6.22	0.06	0.00	0.00
AD-IA	26	46	AS	28	8.52	1200	1292.5	15.17	7.16	0.11	0.04	0.00
AD-IA	27	26	HM	14	8.66	570.5	616	7.11	7.39	0.50	0.00	0.00
AD-IA	28	47	AS	1	8.68	1018.5	1100.5	12.68	7.45	12.00	0.00	0.00
AD-IA	29	48	AS	1	7.86	1410	1521	19.35	7.30	n/a	n/a	n/a
AD-M	30	49	HM	11	8.91	123	455	5.11	7.03	0.82	0.00	0.00
AD-IA	31	44	CFF	28	8.85	94	102	1.15	7.84	0.07	0.29	0.01
AD-IA	32	45	AS	28	7.78	272	294	3.78	7.48	n/a	n/a	n/a
AD-IA	33	52	HM	28	10.05	596	642.5	6.39	7.24	0.04	0.00	0.00
AD-IA	34	50	CFF	56	5.4	16.5	17	0.31	2.94	0.02	0.02	0.00
AD-IA	35	44	CFF	28	8.99	756	814	9.05	7.13	0.00	0.11	0.00
AD-IA	36	53	HM	28	8.96	2040	2189.5	24.44	6.83	0.00	0.00	0.00
AD-IA	37	45	AS	21	9.44	446.5	478.5	5.07	6.69	4.24	1.62	0.08
AD-U	38	57	AS	11	6.2	769	818	13.19	5.99	0.45	0.27	0.01
AD-U	39	55	AS	1	8.04	825	888	11.04	7.09	n/a	n/a	n/a
AD-IA	40	59	CFF	28	9.23	513	557	6.03	7.90	0.00	0.00	0.00
AD-IA	41	60	SS	28	5	13.5	14	0.28	3.57	0.00	0.00	0.00
AD-IA	42	54	AS	14	8.95	532.5	571	6.38	6.74	0.71	0.29	0.01
AD-M	43	64	CFF	14	9.05	281	307	3.39	8.47	0.00	0.00	0.00
AD-IA	45	63	FL	28	7.5	35	36.5	0.49	4.11	n/a	n/a	n/a
AD-IA	46	65	FD	3	11.51	79.5	86	0.75	7.56	n/a	n/a	n/a
AD-U	48	74	CFF	28	8.91	739	796	8.93	7.16	0.00	0.00	0.00
AD-IA	49	71	NFF	7	5.5	205	208.5	3.79	1.68	0.00	0.14	0.02
AD-IA	50	76	WF	28	9.86	941.5	985.5	9.99	4.46	0.43	0.07	0.00
AD-IA	51	77	NFF	4	9.91	460.5	497	5.02	7.34	n/a	n/a	n/a
AD-IA	52	79	NFF	3	10.65	456.5	496	4.66	7.96	n/a	n/a	n/a
AD-IA	53	81	AS	3	8.74	955	1024	11.72	6.74	n/a	n/a	n/a
AD-IA	54	73	NFF	3	9.26	864	940	10.15	8.09	n/a	n/a	n/a
AD-IA	55	68	HM	28	6.8	619	645	9.49	4.03	0.07	0.04	0.00
AD-U	56	82	FL	3	11.13	357	388	3.49	7.99	0.00	0.00	0.00
AD-IA	57	84	FL	12	2.38	158	169.5	7.12	6.78	0.00	0.00	0.00
AD-IA	58	94	TS	28	5.43	82	91	1.68	9.89	0.14	0.00	0.00
AD-IA	59	95	TS	28	5.55	65	73	1.32	10.96	0.04	0.00	0.00
AD-IA	60	90	TS	28	4.7	106.5	117	2.49	8.97	0.25	0.07	0.00
AD-IA	62	91	WF	28	5.13	471.5	512.5	9.99	8.00	0.25	0.75	0.02
AD-IA	63	96	CFF	28	4.86	49.5	54.5	1.12	9.17	0.07	0.18	0.01
AD-IA	64	88	CFF	28	4.83	258	284	5.88	9.15	0.11	0.32	0.01
AD-IA	66	98	WF	28	5.68	93.5	102	1.80	8.33	0.21	0.21	0.01
AD-U	67	99	CFF	28	5.43	77	84	1.55	8.33	0.39	0.11	0.00
AD-IA	68	102	AS	2	7.05	551	599.5	8.50	8.09	6.00	0.00	0.00
AD-IA	69	103	CFF	28	4.76	97	108	2.27	10.19	0.68	0.79	0.02

AD-IA	70	104	AS	28	5.69	136	148	2.60	8.11	0.14	0.00	0.00
AD-IA	71	105	CFF	28	4.55	81	89	1.96	8.99	0.04	0.00	0.00
AD-IA	72	106	CFF	0.5	6.07	27	30	0.49	10.00	0.00	0.00	0.00
AD-U	73	107	AS	21	5.8	309.5	337.5	5.82	8.30	0.43	0.38	0.03
AD-IA	74	108	CFF	28	4.95	179.5	196	3.96	8.42	0.14	0.04	0.00
AD-IA	75	109	WF	28	5.05	146	154	3.05	5.19	0.04	0.00	0.00
AD-IA	76	110	WF	28	5.37	130	142	2.64	8.45	0.07	0.00	0.00
AD-IA	77	111	CFF	28	4.69	345	373.5	7.96	7.63	0.61	0.00	0.00
AD-IA	78	112	AS	5	6.19	587	627	10.13	6.38	0.80	0.00	0.00
AD-IA	79	113	WF	28	6.39	58	64	1.00	9.38	0.04	0.04	0.00
AD-IA	80	114	TS	28	5.87	151	168	2.86	10.12	0.00	0.07	0.01
AD-M	81	115	CFF	28	8.41	356	386	4.59	7.77	0.25	0.00	0.00
AD-U	82	120	CFF	28	6.29	50.5	54	0.86	6.48	0.00	0.00	0.00
AD-IA	83	123	CFF	28	6.41	283	310	4.84	8.71	0.07	0.14	0.01
AD-IA	84	121	CFF	14	6.6	326	353	5.35	7.65	0.86	0.21	0.01
AD-IA	85	118	CFF	14	3.39	4	4	0.12	0.00	n/a	n/a	n/a
AD-U	86	101	CFF	14	6.78	91	100.5	1.48	9.45	0.00	0.00	0.00
AD-IA	87	130	CFF	28	5.74	706.5	765.5	13.34	7.71	0.46	0.00	0.00
AD-IA	88	132	CFF	28	7.86	229.5	257	3.27	10.70	0.18	0.00	0.00
AD-IA	90	137	WF	28	6.24	310.5	336.5	5.39	7.73	0.07	0.07	0.00
AD-IA	91	138	CFF	28	7.9	207	225	2.85	8.00	0.04	0.04	0.00
AD-IA	92	136	HM	28	5.59	1067	1142	20.43	6.57	0.25	0.07	0.00
AD-IA	93	140	WF	28	6.42	116.5	128	1.99	8.98	0.14	0.00	0.00
AD-IA	94	127	HM	28	6.95	699.5	756	10.88	7.47	0.04	0.07	0.00
AD-IA	95	133	WF	28	6.01	312	343	5.71	9.04	0.00	0.00	0.00
AD-IA	96	135	AS	28	6.76	855	917	13.57	6.76	0.21	0.11	0.00
AD-IA	97	141	AS	28	4.98	463	495	9.94	6.46	1.32	0.04	0.00
AD-IA	98	142	AS	28	5.78	357.5	385	6.66	7.14	0.18	0.11	0.00
AD-IA	99	146	NFF	0.5	7.35	1190	1274	17.33	6.59	0.00	0.00	0.00
AD-IA	100	148	WF	28	4.75	661	710	14.95	6.90	0.04	0.00	0.00
AD-U	101	147	FL	28	6.26	305.5	336.5	5.38	9.21	0.07	0.18	0.01
AD-IA	102	153	WF	24	8.2	1144	1230	15.00	6.99	0.67	0.04	0.00
AD-IA	103	134	HM	28	7.3	353	388	5.32	9.02	0.14	0.00	0.00
AD-IA	104	128	HM	10	8.15	1734.5	1862	22.85	6.85	1.40	0.20	0.01
AD-IA	105	154	HM	9	7.51	1325	1429	19.03	7.28	0.56	0.22	0.02
AD-IA	106	155	HM	21	7.8	1199.5	1289	16.53	6.94	0.67	0.05	0.00
AD-IA	107	157	HM	10	8.71	897	973	11.17	7.81	0.50	0.00	0.00
AD-IA	108	127	CL	2	7.15	439	469	6.56	6.40	2.00	0.00	0.00
AD-IA	110	152	HM	56	7.43	2357.5	2508	33.76	6.00	1.09	0.04	0.00
AD-IA	111	156	AS	42	7.84	943	1019	13.00	7.46	0.21	0.00	0.00
AD-IA	112	159	AS	28	8.09	930.5	998	12.34	6.76	0.36	0.11	0.00
AD-IA	113	161	NFF	1.5	8.5	118.5	129	1.52	8.14	0.00	0.00	0.00
AD-IA	114	163	NFF	1.5	9.25	140	152	1.64	7.89	0.00	0.00	0.00
AD-IA	115	165	NFF	4.5	7.76	184.5	201	2.59	8.21	0.00	0.00	0.00
AD-IA	116	156	CL	1.5	8.35	329	359	4.30	8.36	0.00	0.00	0.00
AD-IA	117	159	CL	2	6.86	1268	1353.5	19.73	6.32	0.00	0.00	0.00
AD-IA	118	156	CL	1	7.61	410.5	447.5	5.88	8.27	0.00	0.00	0.00
AD-IA	119	156	CL	1.5	6.34	295	322.5	5.09	8.53	0.00	0.00	0.00
AD-IA	120	156	AS	2	6.13	716	775	12.64	7.61	0.00	0.00	0.00
AD-IA	121	158	HM	6	8.33	1117	1196	14.36	6.61	0.17	0.00	0.00
AD-U	122	169	WF	14	7.74	458	504	6.51	9.13	0.14	0.07	0.00
AD-IA	123	166	AS	28	8.28	2084	2255	27.23	7.58	0.14	0.18	0.01
AD-IA	124	167	HM	28	8.59	1379.5	1516.5	17.65	9.03	0.18	0.04	0.00
AD-IA	125	177	FL	28	7.39	529.5	578.5	7.83	8.47	0.14	0.04	0.00
AD-IA	126	180	HM	28	10.72	1139	1206	11.25	5.56	0.00	0.00	0.00
AD-IA	127	181	FL	28	8.21	1006	1098	13.37	8.38	0.21	0.04	0.00
AD-IA	128	181	CL	1	7.83	479	517	6.60	7.35	0.00	0.00	0.00
AD-IA	129	183	HM	7	7.45	504	553	7.42	8.86	0.00	0.00	0.00
AD-IA	130	184	HM	10	8.5	328	357.5	4.21	8.25	0.00	0.00	0.00
AD-IA	133	190	NFF	14	8.28	370	406	4.90	8.87	0.00	0.00	0.00
AD-IA	134	190	CL	1	7.38	206.5	227.5	3.08	9.23	0.00	0.00	0.00
BO-U	1	8	CFF	14			0	0.00	n/a	0.00	0.00	0.00
BO-LIA/N	2	9	WBS	14			10	0.09	n/a	0.07	0.29	0.01
BO-U	3	10	CFF	14			14	0.12	n/a	0.07	0.00	0.00
BO-LIA/N	4	12	WBS	14			6	0.05	n/a	0.07	0.00	0.00
BO-U	5	11	CFF	14			34	0.30	n/a	0.00	0.00	0.00
BO-U	6	13	CFF	14			27	0.23	n/a	0.00	0.00	0.00
BO-U	7	17	CFF	14			7	0.06	n/a	0.07	0.07	0.00
BO-N	8	20	FL	14			35	0.30	n/a	0.79	0.00	0.00

BO-U	9	24	CFF	14			16	0.14	n/a	0.07	0.00	0.00
BO-U	10	25	CFF	14			20	0.17	n/a	0.07	0.00	0.00
BO-LIA/N	11	14	CFF	14			30	0.26	n/a	0.29	0.14	0.00
BO-U	12	15	CFF	14			10	0.09	n/a	n/a	n/a	n/a
BO-U	13	16	CFF	14			366	3.18	n/a	n/a	n/a	n/a
BO-N	14	26	M	24			47	0.41	n/a	0.88	0.25	0.01
BO-U	15	34	CFF	14			65	0.57	n/a	0.36	0.14	0.00
BO-U	18	43	CFF	14			11	0.10	n/a	0.00	0.07	0.00
BO-U	19	44	CFF	14			9	0.08	n/a	0.00	0.00	0.00
BO-U	20	45	CFF	14			10	0.09	n/a	0.21	0.00	0.00
BO-U	22	50	M	56			30	0.26	n/a	0.45	0.39	0.01
BO-U	23	48	CFF	14			20	0.17	n/a	0.07	0.00	0.00
BO-U	24	50	M	14			30	0.26	n/a	0.14	1.00	0.03
BO-U	25	51	CFF	14			23	0.20	n/a	n/a	n/a	n/a
BO-N	26/27	53	M	70			381	3.31	n/a	6.29	2.29	0.09
BO-N	28	59	M	14			867	7.54	n/a	0.36	0.00	0.00
BO-N	29	59	M	42			867	7.54	n/a	0.36	0.12	0.01
BO-N	30	56	M	14			71	0.62	n/a	2.07	0.00	0.00
BO-N	31	58	M	14			221	1.92	n/a	0.43	0.07	0.00
BO-N	32	58	M	42			221	1.92	n/a	2.90	0.24	0.01
BO-N	33	60	M	14			119	1.03	n/a	2.07	0.00	0.00
BO-N	34	60	M	56			119	1.03	n/a	1.71	0.07	0.01
BO-N	35	61	WBS	14			45	0.39	n/a	0.00	0.00	0.00
BO-N	36	64	M	14			380	3.30	n/a	57.07	4.36	0.21
BO-LIA	38	71	WBS	14			14	0.12	n/a	0.00	0.00	0.00
BO-N	39	53	M	14			381	3.31	n/a	9.50	0.21	0.10
BO-LIA	40	73	WBS	14			24	0.21	n/a	0.00	0.00	0.00
BO-LIA/N	41	75	R	14			21	0.18	n/a	0.00	0.00	0.00
BO-LIA	42	74	WBS	14			11	0.10	n/a	0.00	0.00	0.00
BO-LIA/N	43	78	CFF	14			10	0.09	n/a	0.07	0.00	0.00
BO-LIA	44	79	WBS	14			18	0.16	n/a	0.07	0.00	0.00
BO-LIA/N	45	80	CFF	14			48	0.42	n/a	0.07	0.00	0.00
BO-LIA/N	46	81	WBS	14			53	0.46	n/a	0.00	0.00	0.00
BO-LIA/N	47	85	AS	3.5			121	1.05	n/a	n/a	n/a	n/a
BO-LIA/N	48	82	CFF	10			44	0.38	n/a	0.10	0.00	0.00
BO-U	49	84	CFF	14			32	0.28	n/a	0.00	0.00	0.00
BO-LIA/N	50	83	CFF	14			19	0.17	n/a	0.36	0.00	0.00
BO-LIA/N	51	88	CFF	14			34	0.30	n/a	0.43	0.00	0.00
BO-U	52	92	WBS	14			5	0.04	n/a	0.00	0.00	0.00
BO-LIA/N	53	93	CFF	14			17	0.15	n/a	0.00	0.00	0.00
BO-LIA/N	54	94	CFF	1			68	0.59	n/a	0.00	0.00	0.00
BO-LIA/N	55	95	CFF	1			31	0.27	n/a	7.00	0.00	0.00
BO-LIA/N	56	149	CFF	14			16	0.14	n/a	1.00	0.00	0.00
BO-LIA	57	123	M	84			254	2.21	n/a	3.30	0.37	0.01
BO-LIA/N	58	37	CFF	14			7	0.06	n/a	0.00	0.00	0.00
BO-LIA/N	59	125	CFF	14			2	0.02	n/a	0.14	0.00	0.00
BO-LIA/N	60	126	CFF	13			71	0.62	n/a	0.00	0.00	0.00
BO-LIA/N	61	127	CFF	14			5	0.04	n/a	0.07	0.00	0.00
BO-LIA/N	62	129	CFF	14			16	0.14	n/a	0.21	0.00	0.00
BO-LIA/N	63	128	FL	1			26	0.23	n/a	0.00	0.00	0.00
BO-LIA/N	64	130	CFF	14			9	0.08	n/a	0.00	0.00	0.00
BO-N	65	38	M	14			28	0.24	n/a	0.57	0.00	0.00
BO-LIA/N	66	140	CFF	14			34	0.30	n/a	0.07	0.00	0.00
BO-LIA/N	67	141	CFF	14			86	0.75	n/a	0.50	0.00	0.00
BO-U	68	87	CFF	14			40	0.35	n/a	0.50	0.00	0.00
BO-LIA	69	131	WF	7			15	0.13	n/a	n/a	n/a	n/a
BO-LIA	70	132	WF	7			32	0.28	n/a	0.14	0.00	0.00
BO-LIA/N	71	142	CFF	14			12	0.10	n/a	0.21	0.00	0.00
BO-LIA/N	72	96	WF	56			20	0.17	n/a	0.36	0.00	0.00
BO-LIA/N	73	96	WF	14			20	0.17	n/a	0.57	0.00	0.00
BO-LIA/N	74	40	AS	14			204	1.77	n/a	10.07	0.07	0.00
BO-LIA/N	75	166	M	21			13	0.11	n/a	0.24	0.00	0.00
BO-N	76	144	M	2			37	0.32	n/a	0.50	0.00	0.00
BO-LIA/N	77	97	CFF	14			12	0.10	n/a	0.14	0.00	0.00
BO-N	78	59	M	14			207	1.80	n/a	1.79	0.00	0.00
BO-U	79	67	WBS	14			33	0.29	n/a	0.07	0.00	0.00
BO-N	80	68	M	10			459	3.99	n/a	n/a	n/a	n/a
BO-N	81	69	OGS	0.5			13	0.11	n/a	n/a	n/a	n/a
BO-LIA	82	168	OL	14			2	0.02	n/a	0.07	0.00	0.00

BO-LIA	83	169	OL	14			6	0.05	n/a	0.00	0.00	0.00
BO-LIA	84	170	OL	7			11	0.10	n/a	0.00	0.00	0.00
BO-LIA	85	171	OL	14			10	0.09	n/a	0.00	0.00	0.00
BO-LIA/N	86	19	OL	28			44	0.38	n/a	2.61	2.43	0.08
BO-LIA/N	87	33	AS	14			1515	13.17	n/a	21.50	0.00	0.00
BO-N	88	70	WBS	14			10	0.09	n/a	0.07	0.00	0.00
BO-LIA	91	174	M	56			325	2.83	n/a	1.63	0.00	0.00
BO-LIA/N	92	99	M	28			1058	9.20	n/a	2.39	0.21	0.01
BO-LIA/N	93	101	OL	14			27	0.23	n/a	2.50	0.07	0.00
BO-LIA	94	184	CFF	1			1826	15.88	n/a	n/a	n/a	n/a
BO-LIA	95	185	WBS	1			20	0.17	n/a	n/a	n/a	n/a
BO-LIA	96	186	R	1			1220	10.61	n/a	0.00	0.00	0.00
BO-U	97	102	M	35			30	0.26	n/a	0.83	0.00	0.00
BO-U	98	103	CFF	14			15	0.13	n/a	0.93	0.00	0.00
BO-LIA	99	173	FL	14			19	0.17	n/a	0.07	0.00	0.00
BO-U	100	191	WF	14			68	0.59	n/a	2.21	0.00	0.00
BO-LIA	101	200	OL	14			858	7.46	n/a	1.86	0.21	0.00
BO-U	102	199	WF	14			90	0.78	n/a	n/a	n/a	n/a
BO-U	103	201	WF	14			102	0.89	n/a	0.57	0.00	0.00
BO-U	104	72	WBS	14			33	0.29	n/a	0.00	0.00	0.00
BO-LIA/N	105	203	CFF	14			20	0.17	n/a	0.29	0.07	0.00
BO-LIA/N	106	204	CFF	14			6	0.05	n/a	0.07	0.00	0.00
BO-LIA/N	107	107	M	56			820	7.13	n/a	8.14	1.57	0.08
BO-LIA	108	205	R	28			632	5.50	n/a	1.00	0.04	0.00
BO-LIA	109	207	NFF	4			17	0.15	n/a	0.00	0.00	0.00
BO-LIA	110	208	NFF	2			38	0.33	n/a	2.00	6.00	0.05
BO-LIA/N	111	98	M	14			32	0.28	n/a	1.07	3.21	0.23
BO-LIA	112	209	NFF	1			16	0.14	n/a	4.00	0.00	0.00
BO-LIA/N	114	100	CFF	14			16	0.14	n/a	0.50	0.00	0.00
BO-LIA/N	115	104	WBS	14			38	0.33	n/a	0.29	0.00	0.00
BO-LIA/N	116	109	WBS	14			11	0.10	n/a	0.36	0.00	0.00
BO-LIA/N	117	134	WF	14			1034	8.99	n/a	0.43	0.00	0.00
BO-LIA	119	210	NFF	2			80	0.70	n/a	0.50	0.50	0.02
BO-LIA	121	215	WBS	14			25	0.22	n/a	0.14	0.00	0.00
BO-LIA	122	214	M	14			561	4.88	n/a	4.86	0.07	0.00
BO-LIA	123	160	WF	14			23	0.20	n/a	0.50	0.00	0.00
BO-LIA	127	222	WBS	14			54	0.47	n/a	0.21	0.00	0.00
BO-LIA/N	129	120	FL	14			86	0.75	n/a	1.57	0.57	0.05
BO-LIA	130	248	M	21			126	1.10	n/a	4.81	0.14	0.01
BO-LIA/N	131	280	M	14			177	1.54	n/a	2.00	0.07	0.00
BO-LIA/N	135	284	OL	14			132	1.15	n/a	1.21	0.14	0.01
BO-LIA	137	285	M	65			510	4.43	n/a	1.72	0.23	0.01
BO-LIA	138	226	OL	28			28	0.24	n/a	0.61	0.11	0.00
BO-LIA/N	139	286	CFF	28			8	0.07	n/a	0.39	0.11	0.00
BO-LIA/N	140	112	M	224			448	3.90	n/a	3.32	0.13	0.00
BO-LIA	141	251	FL	28			9	0.08	n/a	0.04	0.18	0.01
BO-LIA	142	256	FL	14			76	0.66	n/a	0.57	0.14	0.01
BO-LIA	143	250	FL	98			642	5.58	n/a	0.20	0.00	0.00
BO-LIA	144	227	OL	28			39	0.34	n/a	0.36	0.00	0.00
BO-LIA	145	255	OL	0.5			9	0.08	n/a	n/a	n/a	n/a
BO-LIA	146	254	AS	14			727	6.32	n/a	n/a	n/a	n/a
BO-LIA	148	165	FL	14			52	0.45	n/a	0.21	0.07	0.00
BO-LIA	149	165	FL	0.5			52	0.45	n/a	n/a	n/a	n/a
BO-LIA	150	230	OL	14			49	0.43	n/a	1.07	0.00	0.00
BO-LIA	156	264	FL	28			42	0.37	n/a	0.86	0.00	0.00
BO-LIA	158	263	FL	11			50	0.43	n/a	9.09	0.82	0.01
BO-LIA	159	297	CFF	4			48	0.42	n/a	0.50	0.50	0.01
BO-U	163	313	CFF	9			8	0.07	n/a	0.00	0.00	0.00
BO-LIA	166	317	NFF	14			20	0.17	n/a	0.86	0.00	0.00
BO-LIA	167	316	FL	10			35	0.30	n/a	n/a	n/a	n/a
BO-LIA	168	323	NFF	7			44	0.38	n/a	0.57	0.00	0.00
BO-LIA	169	328	OL	28			7	0.06	n/a	0.04	0.00	0.00
BO-LIA	170.1	318.a	HM	14			1540	13.39	n/a	112.64	0.00	0.00
BO-LIA	171	326	NFF	14			21	0.18	n/a	0.07	0.00	0.00
BO-LIA	172	331	NFF	7			24	0.21	n/a	0.00	0.00	0.00
BO-LIA	173	334	OL	14			23	0.20	n/a	0.29	0.00	0.00
BO-LIA/N	174	219	OL	14			29	0.25	n/a	0.00	0.00	0.00
BO-LIA	175	361	NFF	3			39	0.34	n/a	1.67	0.00	0.00
BO-LIA	176	358	NFF	8			31	0.27	n/a	2.88	0.00	0.00

BO-LIA/N	181	431	M	84			440	3.83	n/a	3.17	14.56	0.28
BO-E	182	421	FL	28			23	0.20	n/a	0.00	0.00	0.00
BO-E	183	422	FL	1			283	2.46	n/a	n/a	n/a	n/a
BO-LIA	184	419	CFF	14			67	0.58	n/a	1.07	0.00	0.00
BO-LIA/N	186	435	M	56			67	0.58	n/a	0.57	0.04	0.00
BO-LIA/N	188	508	CFF	21			370	3.22	n/a	0.10	0.00	0.00
BO-U	190	603	WF	49			53	0.46	n/a	0.35	0.08	0.00
BO-U	191	601	WF	21			41	0.36	n/a	0.00	0.10	0.00
BO-U	192	607	WF	17			50	0.43	n/a	0.29	0.00	0.00
BO-U	193	602	WBS	14			8	0.07	n/a	0.00	0.00	0.00
BO-LIA	194	612	M	21			22	0.19	n/a	0.10	0.00	0.00
BO-LIA	195	378	WF	28			24	0.21	n/a	0.18	0.00	0.00
BO-LIA	199	390	CFF	28			25	0.22	n/a	0.00	0.00	0.00
BO-LIA	200	513	AS	35			14	0.12	n/a	0.89	0.43	0.01
BO-LIA	201	622	WF	28			23	0.20	n/a	0.68	0.07	0.00
BO-LIA	203	514	AS	28			31	0.27	n/a	0.32	0.07	0.00
BO-E	204	632	NFF	35			22	0.19	n/a	0.29	0.06	0.00
BO-U	213	609	WF	28			42	0.37	n/a	0.07	0.00	0.00
BO-LIA/N	220	517	CFF	14			20	0.17	n/a	0.29	0.00	0.00
BO-LIA	221	518	OL	14			33	0.29	n/a	0.86	0.07	0.00
BO-LIA	222	615	WF	28			26	0.23	n/a	0.11	0.00	0.00
BO-LIA/N	223	519	OL	14			36	0.31	n/a	0.07	0.00	0.00
BO-U	224	199	WF	21			63	0.55	n/a	0.19	0.00	0.00
BO-U	225	626	WF	21			45	0.39	n/a	0.10	0.19	0.01
BO-LIA	226	479	AS	3			107	0.93	n/a	11.67	5.00	0.09
BO-LIA/N	227	523	OL	14			142	1.23	n/a	0.79	0.07	0.00
BO-U	228	627	WBS	28			9	0.08	n/a	0.07	0.00	0.00
BO-LIA/N	229	524	CFF	14			20	0.17	n/a	0.29	0.00	0.00
BO-U	230	630	WF	14			59	0.51	n/a	0.57	0.14	0.01
BO-LIA/N	231	526	CFF	14			123	1.07	n/a	0.57	0.14	0.00
BO-LIA	232	481	M	28			1158	10.07	n/a	2.04	0.07	0.00
BO-U	234	620	WF	14			101	0.88	n/a	1.50	0.14	0.00
BO-LIA	235	530	NFF	14			16	0.14	n/a	0.00	0.00	0.00
BO-LIA	236	529	OL	14			21	0.18	n/a	0.21	0.00	0.00
BO-U	237	653	WF	14			82	0.71	n/a	n/a	n/a	n/a
BO-LIA	238	531	OL	28			28	0.24	n/a	0.43	0.00	0.00
BO-LIA/N	239	532	CFF	21			25	0.22	n/a	0.38	0.24	0.01
BO-U	240	650	WF	56			920	8.00	n/a	2.82	0.27	0.01
BO-U	241	533	NFF	14			27	0.23	n/a	0.86	0.00	0.00
BO-LIA/N	242	33	AS	14			1358	11.81	n/a	12.00	0.00	0.00
BO-U	243	429	WF	28			71	0.62	n/a	0.54	0.18	0.01
BO-U	244	658	OGS	14			19	0.17	n/a	0.79	0.00	0.00
BO-LIA/N	245	535	CFF	14			24	0.21	n/a	2.64	0.07	0.00
BO-LIA	246	659	NFF	14			107	0.93	n/a	0.71	0.43	0.01
BO-LIA	247	537	OL	35			79	0.69	n/a	0.63	0.11	0.00
BO-E	252	660A	M	14			151	1.31	n/a	0.43	0.00	0.00
BO-LIA	253	498	OL	14			60	0.52	n/a	2.57	0.71	0.02
BO-U	254	652	WF	17			14	0.12	n/a	n/a	n/a	n/a
BO-LIA	255	684	NFF	14			85	0.74	n/a	0.57	0.07	0.01
BO-LIA	256	676/677	WF	14			47	0.41	n/a	0.43	0.14	0.01
BO-U	259	397	WF	14			61	0.53	n/a	0.43	0.07	0.00
BO-LIA	263	363	WF	14			18	0.16	n/a	4.93	0.00	0.00
BO-LIA	264	364	WF	14			33	0.29	n/a	0.64	0.07	0.00
BO-U	265	826	WF	2			1754	15.25	n/a	8.00	0.00	0.00
BO-LIA	266	827	M	3			36	0.31	n/a	0.33	0.00	0.00
BO-LIA	268	575	NFF	14			334	2.90	n/a	n/a	n/a	n/a
BO-U	269	816	WF	14			40	0.35	n/a	1.71	0.07	0.00
BO-LIA	270	829	NFF	3			480	4.17	n/a	0.33	0.00	0.00
BO-E	271	831	NFF	14			41	0.36	n/a	0.50	0.14	0.01
BO-U	272	822	WF	14			42	0.37	n/a	0.71	0.00	0.00
BO-LIA	276	575	NFF	14			334	2.90	n/a	8.71	0.07	0.00
BO-LIA	277	574	HM	28			1022	8.89	n/a	10.86	0.36	0.02
BO-LIA	285	624	NFF	21			45	0.39	n/a	0.14	0.00	0.00
BO-LIA	286	862	HM	24			1243	10.81	7.50	3.58	0.33	0.06
BO-LIA	288	742	HM	14			39	0.34	4.50	1.14	0.07	0.00
BO-LIA	289	354	FL	14			101	0.88	n/a	7.36	0.00	0.00
BO-LIA	292	867	HM	10			121	1.05	7.50	3.40	0.00	0.00
BO-LIA	293	868	NFF	10			101	0.88	n/a	4.20	0.30	0.01
BO-LIA	295	727	NFF	1.5			110	0.96	8.10	2.00	0.00	0.00

BO-LIA	297	717	M	28			204	1.77	7.40	0.79	0.00	0.00
BO-LIA	305	882	NFF	14			19.6	0.17	8.30	0.00	0.00	0.00
BO-LIA/N	311	586	M	28			328	2.85	6.60	2.29	2.39	0.10
BO-LIA	322	875	NFF	14			183	1.59	1.60	0.29	0.00	0.00
BO-LIA	325	738	HM	28			1333	11.59	7.60	9.00	0.00	0.00
BO-LIA	330	749	HM	14			377	3.28	6.20	15.64	0.07	0.00
BO-LIA	331	888	HM	28			1212	10.54	6.30	9.32	0.00	0.00
CC-3		121	AS	43	6.83	528.5	570	8.35	7.28	6.63	n/a	0.01
CC-3		122	AS	17	5.9	238.5	257.5	4.36	7.38	6.47	n/a	0.01
CC-1		123	NFF	4	6.03	39.5	42.5	0.70	7.06	3.25	n/a	0.02
CC-1		124	NFF	10	6.73	36	37	0.55	2.70	0.20	n/a	0.00
CC-3		125	NFF	9	5.27	40	42.5	0.81	5.88	0.11	n/a	0.02
CC-1		126	NFF	14	8.24	11	11.5	0.14	4.35	0.21	n/a	0.00
CC-2		128	OGS	9	6.57	8	8.5	0.13	5.88	0.00	n/a	0.00
CC-3		129	AS	13	5.51	148	160.5	2.91	7.79	2.38	n/a	0.03
CC-3		134	AS	5	5.54	1012	1090.5	19.68	7.20	27.40	n/a	0.02
CC-3		135a	AS	22	5.57	1366	1476	26.50	7.45	12.77	n/a	0.01
CC-3		135b	AS	ss	7.03	364	393	5.59	7.38	n/a	n/a	n/a
CC-3		137	AS	10	5.63	462.5	498.5	8.85	7.22	4.10	n/a	0.00
CC-U		146	NFF	3	8.17	9.5	10.5	0.13	9.52	1.33	n/a	0.02
CC-U		147	NFF	ss	6.06	14	14	0.23	0.00	n/a	n/a	n/a
CC-U		149	NFF	2	6.16	6.5	6.5	0.11	0.00	0.50	n/a	0.03
CC-2		154	OGS	11	7.6	53.5	56.5	0.74	5.31	1.09	n/a	0.00
CC-2		160	OGS	ss	7.01	86.5	91	1.30	4.95	n/a	n/a	n/a
CC-2		161	OGS	ss	8.24	42	46	0.56	8.70	n/a	n/a	n/a
CC-2		162	OGS	ss	7.82	50.5	52.5	0.67	3.81	n/a	n/a	n/a
CC-2		163	OGS	ss	8.48	29.5	32	0.38	7.81	n/a	n/a	n/a
CC-3		164	NFF	5	5.46	18.5	20	0.37	7.50	0.40	n/a	0.00
CC-1		165a	NFF	10	7.45	18	18	0.24	0.00	0.00	n/a	0.00
CC-1		165b	NFF	ss	8.47	23	23	0.27	0.00	n/a	n/a	n/a
CC-3		167	NFF	3	6.63	417	453	6.83	7.95	2.33	n/a	0.00
CC-2		170	OGS	2	6.02	16	17	0.28	5.88	0.00	n/a	0.00
CC-2		172	NFF	2	6.68	14	15	0.22	6.67	0.00	n/a	0.00
CC-2		176	NFF	ss	5.99	14	14.5	0.24	3.45	n/a	n/a	n/a
CC-3		177	AS	11	6.97	215	229.5	3.29	6.32	5.91	n/a	0.05
CC-3		180	AS	17	6.7	169	182	2.72	7.14	16.71	n/a	0.01
CC-3		181	AS	18	6.44	248	266.5	4.14	6.94	19.44	n/a	0.02
CC-3		183	NFF	ss	8.11	274.5	294	3.63	6.63	n/a	n/a	n/a
CC-3		184	NFF	ss	7.57	45	48	0.63	6.25	n/a	n/a	n/a
CC-3		186	NFF	2	8.82	91	97.5	1.11	6.67	1.00	n/a	0.00
CC-4		193	NFF	2	6.8	17	17	0.25	0.00	0.00	n/a	0.00
CC-4		194	NFF	2	7.26	156.5	169	2.33	7.40	4.50	n/a	0.00
CC-4		195	NFF	ss	7.43	54.5	59.5	0.80	8.40	n/a	n/a	n/a
CC-1		196	NFF	2	7.32	32.5	33	0.45	1.52	0.50	n/a	0.00
CC-1		197	NFF	2	7.71	57	60	0.78	5.00	1.00	n/a	0.00
CC-1		198	NFF	2	6.73	58.5	60.5	0.90	3.31	2.50	n/a	0.02
CC-1		199	NFF	2	6.91	48.5	51	0.74	4.90	1.00	n/a	0.00
CC-1		200	NFF	1	7.78	129.5	139.5	1.79	7.17	n/a	n/a	0.09
CC-1		201	NFF	1	9.77	81	84	0.86	3.57	0.00	n/a	0.00
CC-1		202	NFF	ss	7.96	73	78.5	0.99	7.01	n/a	n/a	n/a
CC-1		203	NFF	1	7.15	30.5	33	0.46	7.58	0.00	n/a	0.04
CC-1		204	NFF	ss	7.63	58.5	63	0.83	7.14	n/a	n/a	n/a
CC-1		205	NFF	ss	6.7	22	23.5	0.35	6.38	n/a	n/a	n/a
CC-1		206	NFF	ss	8.75	22.5	23	0.26	2.17	n/a	n/a	nn
CC-1		207	NFF	ss	8.44	37.5	40	0.47	6.25	n/a	n/a	n
CC-1		208	NFF	2	7.15	31	31	0.43	0.00	0.00	n/a	0.00
CN-R	1	20	FL	3.5	9.62	103.5	115.5	1.20	10.39	8.6	1.71	0.05
CN-R	2	33	NFF	3.0	11.28	259	279	2.47	7.17	2.0	0.33	0.01
CN-R	4	34	WBS	1.5	12.24	116.5	124	1.01	6.05	0.7	0.67	0.01
CN-R	6	18	CFF	1.5	9.84	384	415	4.22	7.47	7.3	2.00	0.07
CN-R	8	47	CFF	3.0	8.56	1124	1218.5	14.23	7.76	1.3	1.00	0.02
CN-R	9	46	CFF	2.0	11.3	202.5	218	1.93	7.11	2.5	7.00	0.25
CN-R	10	41	CFF	2.0	9.19	549.5	592	6.44	7.18	0.5	0.00	0.00
CN-C	11	71	OL	2.0	10.25	598	644.5	6.29	7.21	3.0	1.00	0.05
CN-R	12	43	FL	2.0	11.59	314	339	2.92	7.37	3.5	26.50	1.37
CN-R	13	83	FL	2.0	9.49	631.5	683.5	7.20	7.61	16.0	2.50	0.08
CN-C	14	67	CFF	2.0	13.04	127	137	1.05	7.30	0.0	0.00	0.00
CN-R	16	83	FL	7.0	10.97	133	144	1.31	7.64	2.9	3.57	0.15
CN-C	17	84	CFF	4.5	7.95	180.5	197	2.48	8.38	3.1	0.00	0.00

CN-W	20	90	AS	1.0	10.4	338	362.5	3.49	6.76	1.0	30.00	1.26
CN-C	22	103	OL	2.0	7.05	199	214	3.04	7.01	2.0	5.00	0.12
CN-C	24	71	OL	1.5	10.5	308.5	331	3.15	6.80	2.0	18.00	0.75
CN-C	32	153	OL	1.5	9.95	270	291	2.92	7.22	1.3	0.67	0.01
CN-C	33	157	WF	1.0	8.42	97	103	1.22	5.83	2.0	0.00	0.00
CN-U	41	10	M	3.5	8.45	450.5	485	5.74	7.11	3.1	0.00	0.00
CN-R	61	166	NFF	2.0	9.53	294	321.5	3.37	8.55	12.0	2.00	0.07
CN-C	62	182	FL	1.5	11	248	267	2.43	7.12	8.7	0.00	0.00
CN-W	63	187	AS	3.0	8.2	1283.5	1396.5	17.03	8.09	2.3	0.33	0.01
CN-C	64	193	FD	2.0	10.39	285.5	307	2.95	7.00	4.0	2.50	0.11
CN-C	66	193	FD	2.0	8.81	147	158	1.79	6.96	0.0	0.00	0.00
CN-W	70	201	FL	1.0	13.32	68.95	72.45	0.54	4.83	13.0	4.00	0.11
CN-C	80	243	M	1.0	9.45	237.5	258.5	2.74	8.12	3.0	0.00	0.00
CN-C	83	251	CFF	3.0	10.04	317	342	3.41	7.31	4.3	1.00	0.03
CN-W	88	296	CFF	2.0	8.01	426	457.5	5.71	6.89	4.0	1.00	0.04
CN-C	89	284	AS	2.0	6.95	443	477	6.86	7.13	1.0	0.50	0.39
CN-C	90	279	AS	2.0	5.48	166.5	179	3.27	6.98	1.5	34.00	0.83
CN-C	91	280	HM	3.0	4.3	529	569	13.23	7.03	2.0	10.00	0.54
CN-R	xx	18	CL	1.0	12.64	36.1	36.1	0.29	0.00	0.0	0.00	0.00
CN-R	xx	30	CFF	1.0	11.9	206	222.5	1.87	7.42	0.0	0.00	0.00
CN-W	xx	173	AS	0.1	6.27	27.9	27.9	0.44	0.00	0.0	0.00	0.00
CN-W	xx	201	FL	1.0	7.79	39	41	0.53	4.88	0.0	0.00	0.00
CN-W	xx	224	CFF	1.5	10.58	42.1	44.15	0.42	4.64	0.7	2.67	0.05
CN-C	xx	266	FL	2.5	5.92	142.5	153	2.58	6.86	3.2	2.80	0.24
DB-S	87/3	183	CL	ss	10.49	30	31	0.30	3.23	n/a	n/a	n/a
DB-M	87/4	177	OL	0.5	3.86	2.5	3	0.08	16.67	4	0.00	0.00
DB-M	87/6	176a	OL	5	5.06	248	266	5.26	6.77	0.4	0.00	0.00
DB-M	87/7	176b	OL	ss	7.35	546	586	7.97	6.83	n/a	n/a	n/a
DB-M	87/8A	177	OL	ss	4.04	47.5	51	1.26	6.86	n/a	n/a	n/a
DB-M	87/8B	177	OL	ss	5.54	56	58	1.05	3.45	n/a	n/a	n/a
DB-S	87/9	204	HM	ss	9.82	38	41	0.42	7.32	n/a	n/a	n/a
DB-S	87/13	210	HM	5	4.62	1525	1624	35.15	6.10	0.6	0.80	0.02
DB-S		14	WF	ss	8.49	1561	1601	18.86	2.50	n/a	n/a	n/a
DB-S		137	CL	ss	9.34	38	39	0.42	2.56	n/a	n/a	n/a
DB-P		158	OL	5	6.4	7.5	8	0.13	6.25	12.2	5.60	0.24
DB-P		158	NFF	ss	6.03	45	48	0.80	6.25	n/a	n/a	n/a
DB-S		161	CFF	5	4.48	4.5	5	0.11	10.00	1.6	0.20	0.00
DB-M		163	OL	ss	8.46	17	17.5	0.21	2.86	n/a	n/a	n/a
DB-S		164	CFF	5	9.32	5	5	0.05	0.00	0.6	0.20	0.00
DB-S		165	HM	5	4.62	887	956	20.69	7.22	1	0.20	0.00
DB-S		203	HM	ss	8.31	363	391	4.71	7.16	n/a	n/a	n/a
DB-M		206	OL	5	4.31	5	5	0.12	0.00	8.8	0.40	0.00
DB-S		131a	HM	5	6.09	858	924	15.17	7.14	0.4	0.40	0.01
GAL-N/M	2	165 (B/1)	M	7	8.21	615.5	666	8.11	7.58	270.29	1.86	0.07
GAL-N/M	3	166 (B/2)	M	7	12.09	124.5	135	1.12	7.78	3.43	0.43	0.03
GAL-N/M	4	147 (B/4)	HM	7	9.58	1040	1124	11.73	7.47	2.43	0.00	0.00
GAL-LIA	5	300 (A/1)	FL	4	12.55	84.5	89.5	0.71	5.59	1.00	0.50	0.01
GAL-LIA	6	301 (A/2)	FL	4	11.43	265.5	285	2.49	6.84	5.75	2.50	0.05
GAL-N/M	10	205 (B/3)	FL	4	10.19	242.5	262	2.57	7.44	3.25	0.25	0.02
GAL-N/M	11	157 (B/20)	M	2	12.86	133	142	1.10	6.34	3.50	0.00	0.00
GAL-N/M	12	136 (B/21)	WBS	ss	12.59	71.5	75	0.60	4.67	n/a	n/a	n/a
GAL-N/M	13	140 (B/22)	M	4	11.67	80	85	0.73	5.88	2.50	0.00	0.00
GAL-N/M	14	203 (B/23)	WBS	ss	13.21	45.9	48	0.36	4.38	n/a	n/a	n/a
GAL-N/M	15	204 (B/24)	CFF	12	13.1	73	78	0.60	6.41	3.17	0.00	0.00
GAL-N/M	16	159 (B/25)	WBS	ss	14.17	21.5	22.55	0.16	4.66	n/a	n/a	n/a
GAL-N/M	17	137 (B/26)	WBS	ss	13.76	44.05	46.3	0.34	4.86	n/a	n/a	n/a
GAL-N/M	50	112a	FL	3	11.27	182.5	190.5	1.69	4.20	2.33	0.00	0.00
GAL-N/M	51	112b	AS	2	9.41	522	537	5.71	2.79	9.50	0.00	0.00
GAL-N/M	52	133	M	3	8.38	480	524.5	6.26	8.48	9.00	0.00	0.00
GAL-N/M	53	134	M	2	9.11	490	522	5.73	6.13	8.00	0.00	0.00
GAL-N/M	54	135	AS	1	7.94	831.5	873.5	11.00	4.81	1.00	0.00	0.00
GAL-N/M	55	114	M	3	10.19	202	217	2.13	6.91	25.00	0.33	0.01
GAL-N/M	56	127	AS	0.5	11.57	144.5	157	1.36	7.96	10.00	0.00	0.00
GAL-N/M	57	131	FL	3	8.31	225.5	247	2.97	8.70	12.00	0.33	0.06
GAL-N/M	58	132	OGS	1	11.63	143	156	1.34	8.33	5.00	0.00	0.00
GAL-LIA	59	400	AS	2	6.29	1546.5	1668	26.52	7.28	15.50	0.00	0.00
GAL-LIA	60	401	FL	1.5	9.43	154.5	169	1.79	8.58	2.00	0.00	0.00
GE	1	5	TS	28	7.7	5	5	0.06	0.00	0.3	0.00	0.00
GE	2	9	OL	28	7.78	11.5	12	0.15	4.17	0.1	0.00	0.00

GE	3	10	SS	12	7.56	7	8	0.11	12.50	0.0	0.00	0.00
GE	4	6	SS	28	8.64	2	2	0.02	0.00	0.0	0.00	0.00
GE	5	8	OL	28	6.76	5.5	6	0.09	8.33	0.7	0.43	0.04
GE	6	6	SS	14	7.78	7.5	8	0.10	6.25	0.1	0.00	0.00
GE	7	12	SS	28	9.42	3	3	0.03	0.00	0.0	0.00	0.00
GE	8	16	TS	28	7.15	4	4	0.06	0.00	0.2	0.14	0.01
GE	9	13	TS	28	5.68	2	2	0.04	0.00	0.2	0.25	0.05
GE	10	14	OL	28	7.95	17	18	0.23	5.56	0.7	0.57	0.04
GE	11	25	OL	28	7.04	4.5	5	0.07	10.00	0.2	0.82	0.05
GE	12	28	OL	28	7.22	8	9	0.12	11.11	2.1	0.36	0.03
GE	13	29	OL	28	6.42	3	3	0.05	0.00	0.3	0.68	0.11
GE	14	30	OL	28	6.03	11	11.5	0.19	4.35	2.4	0.79	0.03
GE	15	34	WF	28	7.21	6	6	0.08	0.00	n/a	n/a	n/a
GE	16	35	NFF	56	6.6	3	3	0.05	0.00	1.1	0.32	0.03
GE	17	40	R	28	7.43	4	4	0.05	0.00	0.1	0.04	0.00
GE	18	41	OL	28	7.35	4	4	0.05	0.00	0.8	0.29	0.03
GE	19	42	OL	28	7.79	8	8.5	0.11	5.88	0.8	3.00	0.51
GE	20	43	OL	28	7.53	7	7	0.09	0.00	0.4	0.14	0.01
GE	21	44	OL	42	5.68	5	5	0.09	0.00	1.4	0.21	0.03
GE	22	23	R	3.5	6.46	4	4	0.06	0.00	n/a	n/a	n/a
GE	23	47	NFF	56	5.74	1	1	0.02	0.00	0.6	1.04	0.07
GE	24	52	NFF	10.5	7.07	29	32	0.45	9.38	0.5	0.38	0.04
GE	25	60	OL	28	7.07	4	4	0.06	0.00	0.1	0.43	0.02
GE	26	61	NFF	1	8.07	6	6	0.07	0.00	n/a	n/a	n/a
GE	27	66	TS	0.5	4.9	0.9	0.95	0.02	5.26	n/a	n/a	n/a
GE	28	67	OL	28	9.64	2.65	2.7	0.03	1.85	0.1	0.18	0.02
GE	29	69	WF	28	8.95	6.9	7.45	0.08	7.38	0.3	0.14	0.01
GE	30	69	OL	0.5	8.27	6.6	7.1	0.09	7.04	n/a	n/a	n/a
GE	31	74	TS	28	8.55	4.35	4.5	0.05	3.33	0.3	0.29	0.03
GE	32	75	TS	28	7.27	1.9	2	0.03	5.00	0.1	0.07	0.01
GE	33	76	OL	28	9.11	3.9	3.95	0.04	1.27	0.2	0.04	0.00
GE	34	69	WF	28	9.63	7.35	7.85	0.08	6.37	1.2	0.36	0.04
GE	35	82	OL	28	8.88	3.65	3.8	0.04	3.95	1.0	0.00	0.00
GE	36	80	TS	28	10.46	3.1	3.15	0.03	1.59	0.4	0.32	0.05
GE	37	85	OL	28	9.28	8	8.6	0.09	6.98	1.6	0.14	0.01
GE	38	84	OL	28	9.69	3.3	3.4	0.04	2.94	0.3	0.21	0.01
GE	39	92	FL	14	9.7	3.5	3.85	0.04	9.09	1.0	0.29	0.02
GE	40	91	AS	28	10.29	37.85	39.55	0.38	4.30	0.3	0.39	0.02
GE	41	87	WF	28	8.87	5.4	5.85	0.07	7.69	1.1	0.32	0.05
GE	42	86	FL	5	11.37	10.95	11.55	0.10	5.19	1.8	1.00	0.06
GE	43	93	AS	6	8.41	55.7	61.25	0.73	9.06	0.0	0.00	0.00
GE	44	94	AS	14	8.47	25.45	27.95	0.33	8.94	0.9	0.07	0.00
GE	45	95	FL	56	8.01	197	201.5	2.52	2.23	1.5	0.05	0.00
GE	46	89	NFF	56	10.45	3.8	4	0.04	5.00	0.2	0.00	0.00
GE	47	96	FL	28	10.57	3.25	3.65	0.03	10.96	0.2	0.04	0.00
GE	48	83	OL	28	10.13	3.05	3.2	0.03	4.69	0.1	0.04	0.01
GE	49	97	FL	28	9.7	3.95	4.2	0.04	5.95	0.6	0.39	0.02
GUN-IA	243	371	AS	14	9.9	714.5	775	7.83	7.81	0.0	0.071	0.001
GUN-IA	245	372	AS	14	10.6	828.5	896.5	8.46	7.59	2.8	1.357	0.028
GUN-IA	253	373	FL	14	9.4	453	486.5	5.18	6.89	4.9	0.357	0.019
GUN-IA	262	390	HM	14	8.6	576	625.5	7.27	7.91	2.2	0.000	0.000
GUN-IA	272	397	AS	14	6.13	364.5	394	6.43	7.49	24.8	0.857	0.026
GUN-IA	307	437	HM	14	7.1	459.5	496	6.99	7.36	1.2	0.357	0.006
GUN-IA	308	436	AS	14	6.4	286	310	4.84	7.74	6.6	0.429	0.027
GUN-IA	309	414	AS	14	6.6	350	379	5.74	7.65	0.2	0.000	0.000
GUN-IA	311	443	HM	7	6.8	360	390	5.74	7.69	1.7	0.143	0.004
GUN-IA	316	449	AS	14	7.4	865.5	933	12.61	7.23	0.4	0.000	0.000
GUN-IA	317	441	FL	14	7	104	113	1.61	7.96	0.0	0.000	0.000
GUN-IA	318	450	FL	14	7.5	88.5	97	1.29	8.76	1.6	0.000	0.000
GUN-IA	341	487	FL	14	7.1	119.5	129	1.82	7.36	0.4	0.143	0.002
GUN-IA	349	448	FL	14	7.6	100	106.5	1.40	6.10	0.0	0.143	0.002
GUN-IA	350	497	FL	14	8.1	75	80	0.99	6.25	1.2	0.429	0.008
GUN-IA	360	514	FL	14	7.4	611	656	8.86	6.86	1.1	0.000	0.000
GUN-IA	365	518	FL	14	7.8	134	146	1.87	8.22	1.6	0.500	0.016
GUN-IA	374	530	FL	14	7.4	129.5	139.5	1.89	7.17	0.4	0.000	0.000
GUN-IA	375	529	HM	14	7.2	486	524.5	7.28	7.34	0.0	0.000	0.000
GUN-IA	388	541	HM	14	7.3	399.5	433	5.93	7.74	0.1	0.571	0.571
GUN-IA	389	540	FL	14	7.1	124	135	1.90	8.15	0.4	0.000	0.000
GUN-IA	393	557	FL	14	7.6	79	86	1.13	8.14	0.6	0.143	0.002

GUN-IA	396	552	OL	14	7.5	5	5	0.07	0.00	0.0	0.000	0.000
GUN-IA	397	553	OL	14	9.8	10.5	11	0.11	4.55	0.1	1.000	0.031
LB-LIA	85/1	6	CFF	0.25	8.94	752	809	9.05	7.05	0.0	0.0	0.0
LB-LIA	86/1	10	CFF	10	8.76	352	380	4.34	7.37	0.7	0.1	0.0
LB-LIA	86/2	10	M	5	6.97	614.5	663	9.51	7.32	4.2	1.4	0.0
LB-LIA	86/3	15	FL	7	8.67	84	90	1.04	6.67	2.3	2.1	0.1
LB-LIA	86/4	19	CFF	3	6.24	563.5	613.5	9.83	8.15	0.0	0.0	0.0
LB-LIA	86/5	11?	R	14	6.98	117.5	128	1.83	8.20	3.4	3.9	0.1
LB-LIA	87/1	75	CFF	6	6.2	379.5	411	6.63	7.66	2.2	2.5	0.1
LB-LIA	87/2	83	NFF	6	7.82	302.5	326	4.17	7.21	18.3	0.0	0.0
LB-LIA	87/3	78	CFF	6	9.1	361	390	4.29	7.44	1.3	9.7	0.5
LB-LIA	87/4	85	CFF	7	6.38	718	770.5	12.08	6.81	4.4	2.3	0.1
LB-LIA	87/5	58	CFF	8	4.72	86.5	93.5	1.98	7.49	4.4	5.0	0.2
LB-U	89/2	270	CFF	6	4.93	16	17	0.34	5.88	0.0	0.0	0.0
LB-C	89/3	246	M	5	6.41	498.5	541.5	8.45	7.94	16.2	3.6	0.1
LB-I	89/4	249	NFF	2	7.73	145.5	159	2.06	8.49	0.5	0.0	0.0
LB-I	89/5	250	NFF	0.5	8.3	143.5	155	1.87	7.42	2.0	2.0	0.1
LB-I	89/6	251	NFF	2	7.68	205.5	222	2.89	7.43	0.5	4.5	0.1
LB-I	89/7	267	NFF	2	6.85	38	40	0.58	5.00	1.0	2.5	0.1
LB-R	101	153	CFF	5	7.43	23.5	25	0.34	6.00	1.8	13.8	0.5
LB-R	102	153	CFF	6	6.49	68.5	72	1.11	4.86	1.2	11.3	0.7
LB-R	103	155	CFF	6	8.08	15	16	0.20	6.25	0.7	1.2	0.1
LB-U	104	197	CFF	7	6.05	10	10	0.17	0.00	0.9	0.0	0.0
LB-C	206	470	HM	4.5	6.76	355	387	5.72	8.27	15.8	74.9	3.4
LB-C	208	476	WF	4	7.29	669.5	718	9.85	6.75	2.3	2.0	0.1
LB-C	213	486	OGS	28	8.41	20	21	0.25	4.76	1.1	0.5	0.0
LB-C	215	487	CFF	28	5.87	41	44	0.75	6.82	1.0	0.9	0.0
LB-C	216	174	WF	28	6.94	10	10	0.14	0.00	1.2	3.3	0.3
LB-C	218	485	CFF	56	7	64	66.5	0.95	3.76	8.2	15.9	0.4
LB-C	219	491	FD	56	5.45	9	9	0.17	0.00	0.6	1.2	0.0
LB-C	220	489	R	14	6.95	59	62	0.89	4.84	0.8	2.1	0.1
LB-C	223	498	CFF	28	7.25	140	151	2.08	7.28	1.0	2.7	0.1
LB-C	229	503	HM	28	9.73	81.5	87	0.89	6.32	32.1	12.9	0.4
LB-C	230	462	FL	56	5.74	10	10.5	0.18	4.76	1.3	8.4	0.3
LB-C	236	507	HM	56	6.11	689.5	740	12.11	6.82	2.7	4.8	0.2
LB-C	237	501	CFF	28	7.61	58.5	63	0.83	7.14	2.5	5.4	0.3
LB-C	240	509	M	11	5.35	148	161	3.01	8.07	2.5	21.5	1.1
LB-C	248	511	OGS	28	8.19	9	9	0.11	0.00	0.8	0.8	0.0
LB-C	257	522	NFF	14	5.08	19.5	20	0.39	2.50	1.9	2.7	0.2
LB-C	264	528	M	7	8.54	14.5	15	0.18	3.33	0.7	0.0	0.0
LB-C	265	531	R	28	5.23	58.5	64	1.22	8.59	1.9	3.2	0.2
LB-C	266	518	OGS	7	5.94	18.5	19.5	0.33	5.13	3.7	2.9	0.1
LB-C	294	539	CFF	28	5.54	105.5	113.5	2.05	7.05	2.2	4.7	0.2
LB-C	295	540	M	11	5.62	113	122	2.17	7.38	3.7	6.0	0.2
LB-C	305	541	FL	56	5.39	40.5	41	0.76	1.22	2.9	2.6	0.2
LB-U	319	452	CFF	56	7.29	43.5	44	0.60	1.14	1.1	1.3	0.1
LB-C	322	552	HM	28	5.18	601	642	12.39	6.39	2.5	3.7	0.1
LB-C	337	556	FD	28	5.05	17.5	18	0.36	2.78	0.8	2.4	0.1
LB-R	344	559	M	161	6.3	86.5	92	1.46	5.98	1.5	21.3	0.8
LB-R	345	567	FD	14	7.77	16	17	0.22	5.88	1.9	3.8	0.1
LB-PR	351	572	CFF	56	4.25	333	359	8.45	7.24	0.6	0.5	0.0
LB-C	354	574	WF	28	6.22	49	52	0.84	5.77	3.0	3.9	0.2
LB-C	361	577	HM	28	4.89	697	749	15.32	6.94	0.9	1.7	0.1
LB-C	366	580	HM	14	6.88	50.5	53.5	0.78	5.61	19.9	2.5	0.1
LB-PR	367	583	CFF	28	6.07	13.5	13.5	0.22	0.00	0.8	4.6	0.2
LB-R	374	553	OGS	28	6.53	110.5	117	1.79	5.56	3.4	0.5	0.0
LB-C	379	578	HM	28	5.62	247.5	266	4.73	6.95	3.8	7.9	0.3

Table 5.1: Mineral magnetic values from all the sites

Site	Soil description	χ range ($\mu m^3 kg^{-1}$)
An Dunan	Topsoil (estuarine saltings)	0.25
An Dunan	Subsoil	0.28
Bostadh	Topsoil (machair sand)	0.08
Bostadh	Wind blown sand	0.04
Calanais kerb cairn	Topsoil (rough grazing)	0.2
Calanais kerb cairn	Subsoil	0.1
Cnip	No control material available	n/a
Dun Bharabhat	No control material available	n/a
Galson	Wind blown sand	0.16
Galson	Raised beach material (equivalent of underlying subsoil)	1.06
Gob Eirer	Topsoil (rough grazing)	0.06
Gob Eirer	Subsoil	0.02
Guinnerso	Topsoil (moorland)	0.08
Guinnerso	Subsoil	0.1
Loch na Beirgh	Topsoil (machair slack)	0.1
Loch na Beirgh	Old ground surface external to broch	0.11

Table 5.2: Mineral magnetic values from 'natural' soil matrixes at all sites

χ range ($\mu m^3 kg^{-1}$)	class midpoint	average QC/l	median QC/l	lowest QC/l	highest QC/l	number of samples
0 - 0.09	0.045	0.23	0.07	0	4	26
0.1 - 0.19	0.145	0.93	0.29	0	12.2	52
0.2 - 0.29	0.245	0.63	0.18	0	7	46
0.3 - 0.39	0.345	0.69	0.4	0	3.71	35
0.4 - 0.49	0.445	0.72	0.21	0	9.09	20
0.5 - 0.74	0.62	1.34	0.57	0	13	30
0.75 - 0.99	0.87	4.09	1.21	0	32.07	26
1.00 - 1.49	1.245	1.92	1.17	0	10	32
1.5 - 1.99	1.745	1.48	0.43	0	10.07	29
2.00 - 2.99	2.495	4.35	2.18	0.21	25	14
3.00 - 3.99	3.495	5.76	2	0	57.07	22
4.00 - 4.99	4.495	4.46	1.33	0	19.44	16
5.00 - 7.49	6.245	2.85	0.82	0	24.79	47
7.5 - 9.99	8.745	12.38	0.61	0	270.29	27
10.00 - 12.49	11.245	2.99	2.04	0	12	17
12.5 - 14.99	13.745	10.83	0.36	0	112.64	14
15.00 - 19.99	17.495	3.18	0.56	0	27.4	13
20.00 - 35.15	27.575	3.64	1	0	15.5	9

Table 5.3: QC/litre grouped according to χ values for all sites (except Gob Eirer)

Fire hearth number	Fuel type	Magnetic samples	Volume of ash (litres)	Ash Munsell colour
FH1	Well humified peat	S.9, 10	14	5YR 7/8 Reddish yellow
FH2	Fibrous upper peat	S.15	28	10R 4/8 Red 10R 6/1 Reddish grey
FH3	Wood	S.21	3	GLEY 2 7/1 Light bluish grey GLEY 2 5/1 Bluish grey
FH4	Well humified peat	S.32	11	5YR 7/8 Reddish yellow
FH5	Fibrous upper peat	S.37, 38	14	10R 4/8 Red
FH6	Wood	S.44	3	GLEY 2 7/1 Light bluish grey GLEY 2 5/1 Bluish grey
FH7	Well humified peat	S.54	11	5YR 7/8 Reddish yellow
FH8	Fibrous upper peat	S.58	14	10R 4/8 Red
FH9	Peaty turf	S.62	21	2.5 YR 4/6 Red
FH10	Well humified peat	S.70	7	5YR 7/8 Reddish yellow
FH11	Fibrous upper peat	S.75, 76	17	10YR 4/8 Red
FH12	Wood	S.81	2	GLEY 2 7/1 Light bluish grey
FH13	Well humified peat	S.95	7 (covered with sand)	5YR 7/8 Reddish yellow
FH14	Fibrous upper peat	S.98	14 (covered with sand)	10R 4/8 Red
FH15	Mixture	S.106	7 (covered with sand)	10 YR 4/8 Red
FH16	Well humified peat	S.111, S.116	3 (covered for a year)	5YR 5/8 Yellowish red
FH17	Peaty turf	S.125	3 (covered for a year)	2.5 YR 4/6 Red
FH18	Mixture	S.133	4 (covered for a year)	10 YR 4/8 Red

Table 5.4: Fire hearth descriptions and magnetic samples

Sample	Sample type	A	B	C	D	E	F	G	H	I	J	K	L	M
9	Ash sample (whp)	70.4	8.5	169.3	6.1	3160.9	3401.2	17.1	343.2	0.36	9.21	0.24	0.05	4.88
10	Ash sample (whp)	41.7	8.9	177.4	64.8	1934.7	2432.6	30.9	423.1	2.10	4.57	0.74	0.07	10.16
32	Ash sample (whp)	36.5	7.9	71.8	4.5	1204.0	1387.7	6.6	126.8	0.69	9.49	0.18	0.05	3.48
54	Ash sample (whp)	47.9	7.6	54.7	9.0	816.8	1115.9	7.2	147.8	1.24	5.53	0.15	0.05	3.08
70	Ash sample (whp)	86.0	8.2	103.2	4.7	1262.7	1403.8	11.1	151.6	0.42	8.33	0.13	0.07	1.76
95	Ash sample (whp)	11.7	7.1	31.5	3.3	526.1	739.9	2.4	56.7	1.37	9.29	0.21	0.04	4.84
15	Ash sample (fup)	62.2	5.5	319.5	111.0	7920.2	10220.9	31.4	1003.0	3.54	7.90	0.50	0.03	16.13
37	Ash sample (fup)	39.3	7.4	137.0	54.0	2459.4	3848.0	12.7	357.6	4.24	6.88	0.32	0.04	9.09
38	Ash sample (fup)	37.6	7.4	51.7	10.4	1171.8	1387.7	11.3	302.3	0.92	3.88	0.30	0.04	8.04
58	Ash sample (fup)	65.3	5.1	340.6	114.8	10040.7	12822.9	30.8	1159.4	3.73	8.66	0.47	0.03	17.75
75	Ash sample (fup)	29.9	5.4	193.8	59.7	5034.0	6745.8	15.5	539.2	3.85	9.34	0.52	0.03	18.06
76	Ash sample (fup)	32.3	6.3	173.5	60.0	3537.1	4856.1	15.4	429.7	3.91	8.23	0.48	0.04	13.30
98	Ash sample (fup)	31.0	6.3	152.0	52.0	3395.9	4533.5	11.6	344.8	4.50	9.85	0.37	0.03	11.13
21	Ash sample (wd)	3.3	2.9	11.5	2.4	395.8	521.7	1.0	45.2	2.41	8.76	0.30	0.02	13.62
44	Ash sample (wd)	1.9	5.7	10.0	2.6	141.0	193.4	0.7	13.3	3.79	10.63	0.35	0.05	6.86
81	Ash sample (wd)	1.7	6.5	8.5	2.7	135.9	209.3	0.7	16.7	3.97	8.12	0.40	0.04	9.73
62	Ash sample (pt)	61.3	5.1	283.8	77.0	7148.4	9503.4	29.9	1001.4	2.57	7.14	0.49	0.03	16.34
106	Ash sample (mix)	41.6	4.6	200.3	51.4	5460.2	7465.2	16.4	610.9	3.14	8.94	0.39	0.03	14.68
12	Sand after fire (whp)	0.2	8.6	1.5	0.9	9.6	15.6	0.1	1.1	8.57	8.79	0.68	0.10	7.03
31	Sand after fire (whp)	0.2	7.6	1.5	0.8	9.2	16.4	0.1	1.2	7.57	7.97	0.65	0.09	7.11
52	Sand after fire (whp)	0.1	8.4	1.2	0.7	5.9	10.4	0.1	0.7	8.31	8.08	0.96	0.12	8.29
69	Sand after fire (whp)	0.1	7.5	1.3	0.8	5.7	10.8	0.1	0.7	9.20	7.89	0.89	0.12	7.40
94	Sand after fire (whp)	0.1	7.9	1.4	0.9	6.5	12.0	0.1	0.8	9.41	7.93	1.01	0.12	8.66
17	Sand after fire (fup)	0.2	6.2	2.1	1.0	14.7	22.3	0.1	1.5	7.15	9.89	0.81	0.09	8.64
36	Sand after fire (fup)	0.1	7.4	1.6	1.0	7.4	12.6	0.1	0.9	9.08	8.53	1.48	0.13	11.67
56	Sand after fire (fup)	0.3	6.4	2.6	1.2	40.8	56.5	0.2	3.9	6.77	10.59	0.68	0.05	14.87
73	Sand after fire (fup)	0.3	6.4	3.5	1.5	33.6	52.9	0.2	3.6	6.24	9.25	0.90	0.07	13.62
99	Sand after fire (fup)	0.3	6.2	2.9	1.4	34.9	51.6	0.2	3.5	7.15	10.02	0.72	0.06	12.73
22	Sand after fire (wd)	0.4	4.7	4.0	1.3	63.4	106.1	0.3	7.9	4.36	8.02	0.74	0.04	19.70
43	Sand after fire (wd)	0.1	8.0	1.9	1.1	9.0	15.1	0.1	1.0	8.40	8.65	0.90	0.13	7.12
79	Sand after fire (wd)	0.2	6.8	2.1	1.2	14.4	24.3	0.1	1.7	8.36	8.67	0.95	0.09	10.95
60	Sand after fire (pt)	0.1	6.6	1.4	0.9	5.8	9.9	0.1	0.7	9.28	8.46	1.68	0.14	11.86
1	Beach sand pre-fire	0.0	1.7	1.4	1.0	4.0	8.3	0.1	0.5	10.91	7.36	4.75	0.17	28.14
47	Beach sand pre-fire	0.0	0.0	1.2	0.9	3.0	6.7	0.1	0.4	11.43	6.82	4.80	0.18	26.80
88	Beach sand pre-fire	0.0	1.7	1.4	1.0	4.3	9.7	0.1	0.6	11.60	7.20	2.43	0.14	16.87
91/1	Column sample (whp)	1.3	9.5	6.5	1.2	86.2	98.3	0.5	8.2	2.22	10.56	0.41	0.07	6.22
91/2	Column sample (whp)	7.2	8.3	12.5	2.0	195.7	241.3	1.7	33.7	1.15	5.82	0.24	0.05	4.67
91/3	Column sample (whp)	0.1	7.1	1.6	1.1	4.4	8.9	0.1	0.6	9.58	6.89	1.62	0.18	8.99
91/4	Column sample (whp)	0.0	6.2	1.6	1.1	5.0	9.6	0.1	0.7	9.39	7.11	2.46	0.17	14.77
92/1	Column sample (whp)	2.6	6.8	5.0	0.8	78.8	90.1	0.4	8.0	1.81	9.88	0.17	0.06	3.06
92/2	Column sample (whp)	0.0	19.6	1.3	0.9	4.2	8.8	0.1	0.7	9.36	6.45	2.43	0.15	16.45

92/3	Column sample (whp)	1.9	9.1	11.5	2.3	85.7	114.6	1.0	10.2	2.25	8.41	0.55	0.10	5.48
102/1	Column sample (fup)	37.3	6.0	108.6	36.7	2538.4	3581.3	20.0	658.3	1.84	3.86	0.54	0.03	17.65
102/2	Column sample (fup)	68.1	8.6	205.5	120.1	2797.5	4090.1	43.9	874.0	2.74	3.20	0.64	0.05	12.83
102/3	Column sample (fup)	42.6	6.9	165.2	43.3	3699.4	4930.2	18.5	551.5	2.34	6.71	0.43	0.03	12.94
102/4	Column sample (fup)	0.1	8.1	1.8	1.2	5.7	10.6	0.1	0.7	9.47	7.64	2.25	0.17	13.25
102/5	Column sample (fup)	1.0	6.9	8.1	2.1	75.0	102.5	0.7	9.0	2.97	8.37	0.70	0.08	8.84
96A	Sieved ash (1000)	6.2	9.7	6.8	1.1	94.8	125.4	1.2	22.1	0.92	4.29	0.19	0.05	3.57
96A	Sieved ash (710)	10.3	7.6	18.8	2.2	335.2	441.0	1.8	41.8	1.23	8.01	0.17	0.04	4.06
96A	Sieved ash (500)	18.6	7.3	33.5	2.4	620.6	804.2	2.8	66.7	0.86	9.30	0.15	0.04	3.58
96A	Sieved ash (355)	16.1	6.9	33.7	3.8	629.5	835.9	2.5	63.2	1.49	9.96	0.16	0.04	3.92
96A	Sieved ash (180)	10.1	7.6	27.1	3.0	457.3	621.6	1.9	43.8	1.57	10.44	0.19	0.04	4.35
96A	Sieved ash (125)	20.0	7.6	49.9	5.0	931.1	1286.8	3.8	98.8	1.31	9.43	0.19	0.04	4.94
96A	Sieved ash (90)	39.9	7.3	62.9	7.7	1261.4	1742.0	7.7	213.7	1.00	5.90	0.19	0.04	5.36
96A	Sieved ash (63)	48.2	7.2	77.7	6.6	1525.4	2117.8	10.4	282.8	0.64	5.39	0.22	0.04	5.87
96A	Sieved ash (<63)	50.4	8.1	78.5	7.3	1611.2	2350.0	10.5	315.0	0.69	5.11	0.21	0.03	6.25
96B	Sieved ash (1000)	13.9	8.6	31.7	4.1	583.4	794.8	2.9	72.7	1.41	8.03	0.21	0.04	5.24
96B	Sieved ash (710)	9.4	7.4	24.2	2.3	435.5	587.2	2.0	48.1	1.16	9.05	0.21	0.04	5.14
96B	Sieved ash (500)	15.7	7.2	39.6	2.8	729.8	1020.9	2.9	76.0	0.95	9.60	0.19	0.04	4.85
96B	Sieved ash (355)	12.9	7.4	35.5	3.7	629.8	885.7	2.5	61.2	1.51	10.30	0.19	0.04	4.73
96B	Sieved ash (180)	9.2	7.3	30.4	2.9	513.0	692.3	2.0	46.3	1.43	11.08	0.22	0.04	5.02
96B	Sieved ash (125)	16.7	7.3	49.9	3.8	902.2	1222.7	3.6	87.5	1.06	10.31	0.21	0.04	5.23
96B	Sieved ash (90)	31.8	7.3	65.5	6.6	1262.0	1726.1	8.3	218.2	0.80	5.78	0.22	0.04	5.77
96B	Sieved ash (63)	32.7	7.8	80.1	6.2	1497.3	2076.7	11.8	305.8	0.53	4.90	0.24	0.04	6.19
96B	Sieved ash (<63)	64.43	8.3	50.3	4.3	976.6	1392.5	9.7	267.3	0.45	3.65	0.23	0.04	6.28

Key:

1. Fuel types

whp = well humified peat   fup = fibrous upper peat   wd = wood   pt = peaty turf   mix = mixture

2. Mineral magnetic values

A = χ ($\mu m^3 kg^{-1}$)   B = κ_{fd} (%)   C = ARM_{99mT} (MAm^2kg^{-1})   D = $ARM_{demag40mT}$ (MAm^2kg^{-1})
E = IRM_{60mT} (MAm^2kg^{-1})   F = IRM_{1T} (MAm^2kg^{-1})   G = SARM (MAm^2kg^{-1})   H = SIRM (MAm^2kg^{-1})
I = $ARM_{demag40mT}$/SARM   J = IRM_{60mT}/SIRM   K = SARM/χ L = SARM/SIRM   M = SIRM/χ

Table 5.5: Mineral magnetic results from experimental fire hearths

Sample			96	100	106	120	121	128	129	150	153	156
FH#			FH13	FH14	FH15	FH17	FH17	FH18	FH18	DUMP 1	DUMP 2	DUMP 3
Volume			3	4	3	0.3	1	0.6	0.2	14	14	5
Hearth type			whp	pt	mix	pt	pt	mix	mix	whp	fup	pt & wd
Charcoal	**Common name**	**Plant part**										
Betula sp. roundwood	Birch	roundwood								1F(0.23)		4F(0.33)
Betula sp.	Birch	timber								3F(0.13)		
Calluna vulgaris (L.) roundwood	Ling heather	roundwood								1F(0.04)		
Indet. (vitrified)	Indeterminate	timber								8F(1.07)	2F(0.23)	
Indet. rootwood	Indeterminate	roundwood	2F(0.04)		1F(0.03)							
Pinus sp.	Pine	timber	16F(2.16)	18F(2.41)	17F(9.00)			3F(1.09)		6F(0.2)	17F(1.1)	15F(2.96)
Pinus sp. roundwood	Pine	roundwood	2F(0.21)	2F(0.21)	2F(1.09)						1F(0.83)	
Pinus sp. bark	Pine	bark								1F(0.06)		1F(0.03)
Total fragments in fraction			20	20	20			3		20	20	20
Total fragments			31	80	270			3		49	150	55
Total weight			3.15	6.27	30.19			0.34		3.7	11.5	12.75
Wild species												
Atriplex sp.	Orache	seed									1	
Calluna vulgaris (L.) Hull.	Ling heather	capsule		2						1	1	2
Carex spp. (biconvex)	Sedge	nutlet						2			3	2
Carex spp. (trigonous)	Sedge	nutlet						2		1	8	2
Danthonia decumbens L.	Heath-grass	caryopsis		2			1	1				
Erica/Calluna spp.	Heather	capsule						1				
Montia fontana L.	Blinks	seed									1	1
Poaceae undiff. (medium)	Grass	caryopsis						1				
Rumex spp.	Dock	nutlet									1	
Vaccinium sp.	Bilberry family	seed									2	
Cereal/monocotyledon (>2 mm.)		culm node		2						1		
Cereal/monocotyledon (<2 mm.)		culm node		5				4	1			6
Cereal/monocotyledon (>2 mm.)		culm base		5				3			1	5
Cereal/monocotyledon (<2 mm.)		culm base		25				49	11	4	4	23
Indeterminate (>2 mm.)		rhizome	2	9	1			10	4	1	34	2
Indeterminate (<2 mm.)		rhizome	1	12		1	16	59	12	1	59	8
Indeterminate seed/fruit		seed/fruit									3	5
Indeterminate moss fragment	Moss frond	frond	1F								12F	5F
Ramalina sp.	Lichen frond	fond	P	P	P	P	P	P	P	P	P	P
		Total QC	3	62	1	1	17	132	28	9	118	56
		QC/litre	1.00	15.50	0.33	3.33	17.00	220.00	140.00	0.64	8.43	11.20

Table 5.6: Archaeobotanical results from experimental fire hearths

Sort description	Number of samples	Number of grains	P1 (%)	P2 (%)	P3 (%)	P4 (%)	P5 (%)	P6 (%)
By block								
AD-IA	8	76	0.00	3.95	15.79	22.37	38.16	19.74
AD-M	2	59	0.00	33.90	15.25	11.86	23.73	15.25
BO-E	1	7	0.00	0.00	0.00	28.57	42.86	28.57
BO-LIA	79	13794	0.06	6.12	16.18	15.27	25.25	37.12
BO-LIA/N	26	2385	0.04	3.48	13.25	18.95	23.90	40.38
BO-N	11	1518	0.00	3.23	11.86	12.32	23.85	48.75
CC-3	11	439	0.00	1.14	7.74	14.35	22.10	54.67
CN-W	3	99	1.01	16.16	28.28	11.11	26.26	17.17
CN-C	1	11	0.00	0.00	18.18	27.27	45.45	9.09
CN-R	3	31	0.00	12.90	22.58	16.13	32.26	16.13
DB-P	1	51	0.00	3.92	1.96	5.88	27.45	60.78
DB-S	1	420	32.14	37.86	21.90	4.76	2.86	0.48
GAL-LIA	2	33	0.00	9.09	6.06	9.09	21.21	54.55
GAL-N/M	10	1763	0.00	8.39	16.39	9.47	23.37	42.37
GE	18	382	0.00	2.09	8.90	16.75	27.23	45.03
GUN	10	56	0.00	12.50	19.64	19.64	26.79	21.43
LB-R	1	60	0.00	5.00	11.67	13.33	33.33	36.67
LB-C	20	2791	0.61	7.45	23.68	5.91	32.96	29.38
LB-LIA	4	105	0.00	4.76	24.76	15.24	29.52	25.71
	Total = 212	**Total = 24080**						
By context type								
AS	31	2448	0.04	6.86	17.81	17.36	21.20	36.72
CON	1	420	32.14	37.86	21.90	4.76	2.86	0.48
FL	36	2276	0.13	11.29	27.24	15.38	19.02	26.93
HM	34	9369	0.17	5.30	15.85	12.45	30.37	35.86
M	45	5746	0.02	4.98	14.83	14.01	23.84	42.33
NFF	32	3079	0.19	5.94	12.34	14.00	24.62	42.90
OL	33	742	0.00	2.29	10.51	15.23	26.55	45.42
	Total = 212	**Total = 24080**						
By cereal class								
Hordeum sp.	n/a	5275	0.00	0.00	0.82	12.27	38.35	48.57
H. naked	n/a	32	0.00	6.25	28.13	37.50	28.13	0.00
H. cf. naked	n/a	109	0.00	0.92	7.34	23.85	44.95	22.94
H. naked sym	n/a	22	0.00	31.82	50.00	13.64	4.55	0.00
H. naked asym	n/a	27	0.00	48.15	37.04	11.11	3.70	0.00
H. hulled	n/a	5272	0.00	0.06	3.38	24.03	51.75	20.79
H. cf. hulled	n/a	2127	0.00	0.00	0.47	12.18	43.82	43.54
H. hulled sym	n/a	2223	2.88	22.27	57.00	17.27	0.58	0.00
H. hulled asym	n/a	3691	2.57	23.76	58.98	14.33	0.33	0.03
Hordeum all	n/a	18778	0.85	7.44	19.77	16.67	30.72	24.55
Avena sp.	n/a	963	0.31	16.20	23.05	15.68	28.76	15.99
Triticum sp.	n/a	67	0.00	19.40	11.94	41.79	22.39	4.48
Cereal indet.	n/a	4272	0.00	0.00	0.00	0.02	1.73	98.24

Table 5.7: Cereal grain preservation from archaeological sites

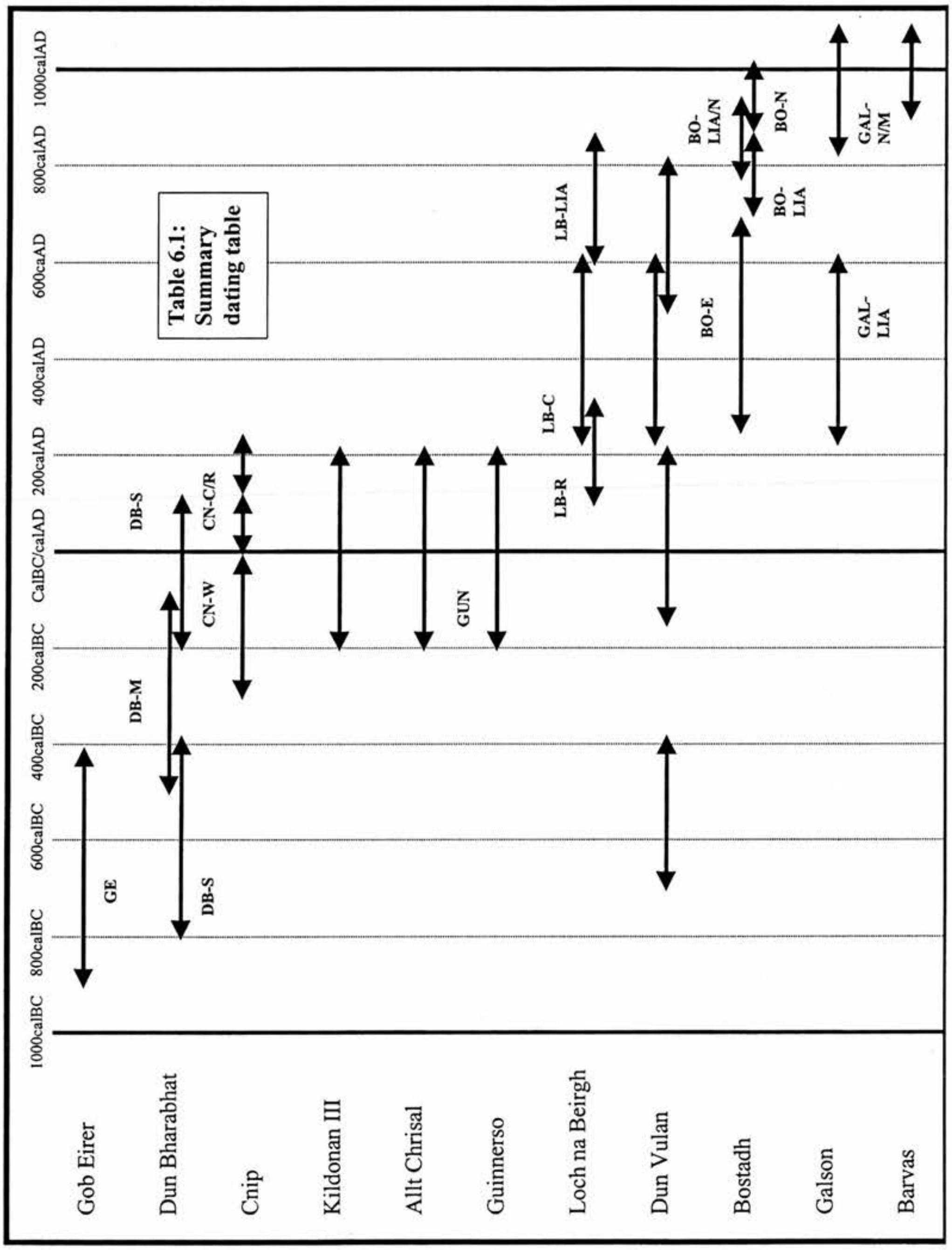


Table 6.1: Summary dating table

General period	Site block
Bronze Age (**BA**) c. 2000 – 700 cal BC	Calanais kerb cairn (**CC-3**)
Early Iron Age (**EIA**) c.700 – 100 cal BC	Gob Eirer (**GE**)
	Dun Bharabhat (**DB-P**)
Mid Iron Age (**MIA**) 200 cal BC –200 cal AD	Dun Bharabhat (**DB-M**)
	Dun Bharabhat (**DB-S**)
	An Dunan (**AD-IA**)
	Guinnerso (**GUN-IA**)
	Cnip (**CN-W**)
	Cnip (**CN-C**)
	Cnip (**CN-R**)
Late Iron Age I (**LIA-I**) 100 – 600 cal AD	Loch na Beirgh (**LB-R**)
	Loch na Beirgh (**LB-C**)
	Galson (**GAL-LIA**)
	Bostadh (**BO-E**)
Late Iron Age II (**LIA-II**) 500 – 900 cal AD	Bostadh (**BO-LIA**)
	Loch na Beirgh (**LB-LIA**)
Late Iron Age / Norse transition (**LIA/N**)	Bostadh (**BO-LIA/N**)
Norse / early Medieval (**N/EM**)	Bostadh (**BO-N**)
	Galson (**GAL-N/M**)
	An Dunan (**AD-M**)

Table 6.2: Site blocks by general period

Period	Block	Number of samples for macrofossil means *	Number of samples for charcoal means #	Mean QC/litre *	Mean grain/litre *	Mean charcoal fragment /litre #	Mean charcoal weight/litre #
BA	CC-3	12	14	11.3	2.2	n/a	0.04
EIA	GE	18	30	1	0.7	0.41	0.04
MIA	DB-P	1	1	12.6	10.2	5.6	0.2
MIA	DB-M	1	3	8.8	0	0.13	0.01
MIA	DB-S	1	4	563.8	84	26.75	2.18
MIA	AD-IA	10	42	2.7	1	0.08	0.01
MIA	GUN-IA	12	24	4.3	0.4	0.27	0.03
MIA	CN-W	3	9	10	8.9	4.65	0.19
MIA	CN-C	1	11	8.7	7.3	6.54	0.27
MIA	CN-R	4	6	9.9	3.1	6.1	0.29
LIA-I	LB-R	1	1	1.5	0.4	21.31	0.81
LIA-I	LB-C	20	23	13.6	8.9	7.87	0.34
LIA-I	GAL-LIA	2	4	10.6	7.9	0.75	0.01
LIA-I	BO-E	1	8	0.3	0.2	0.07	0.01
LIA-II	BO-LIA	80	130	12.5	10.3	0.29	0.01
LIA-II	LB-LIA	4	4	7.3	5.6	1.26	0.04
LIA/N	BO-LIA/N	26	31	4.5	3.7	1.52	0.04
N/EM	BO-N	11	16	7.8	7.2	0.51	0.03
N/EM	GAL-N/M	10	14	34.5	27.7	0.23	0.01
N/EM	AD-M	3	3	2.5	0.9	0.24	0.01

* = Samples standardised by removing mixed generic context types and also samples with less than 10 Quantifiable Components
# = Samples standardised by removing mixed generic context types only.

Table 6.3 Mean standardised values from site blocks

Block	CC-3	GE	DB-P	DB-M	DB-S	AD-IA	GUN-IA	CN-W	CN-C	CN-R	LB-R	LB-C	GAL-LIA
Period	**BA**	**EIA**	MIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	LIA-I	LIA-I	LIA-I
Number of samples	12	18	1	1	1	10	12	3	1	4	1	20	2
Grain													
Hordeum sp. (C)	144	121	11			6	5	11		5	5	323	9
H. *distichon* var. *vulgare* L. (C)					4								
H. *vulgare* var. *vulgare* L. asymmetric (C)					7								
H. *vulgare* var. *vulgare* L. symmetric (C)					14								
H. naked (C)	9	3	1										
H. cf. naked (C)	17	7	1										
H. naked symmetric (C)	5											1	4
H. naked asymmetric (C)	6	1										1	
H. hulled (C)	85	100	9		77	33	15	30	4	9	26	961	4
H. cf. hulled (C)	28	56	6			14	1	15	6	3	12	287	
H. hulled symmetric (C)	12	13			133	6	4	10		2	5	355	
H. hulled asymmetric (C)	24	17			185	8	6	23	1	7	7	611	7
Triticum sp. (C)	2											4	
Avena sp. (C)	4					1	19				1	3	
A. *sativa* L. (C)													
Secale cereale L. (C)													
Linum usitatissimum sp. (S)						1					2	5	
Cereal indeterminate (C)	103	64	23			8	6	10		5	4	243	9
Total grain	**439**	**382**	**51**	**0**	**420**	**77**	**56**	**99**	**11**	**31**	**62**	**2794**	**30**
Chaff													
Cereal indeterminate (AF)	1											1	
Hordeum sp. (RI)					34						2	36	
H. *distichon* var. *vulgare* L. (RI)					28								
H. cf. *distichon* var. *vulgare* L. (RI)					28								
H. *distichon* var. *vulgare* L. (BRI)					9								
H. *distichon* var. *vulgare* L. (SLS)					42							1	
H. *vulgare* var. *vulgare* L. (RI)					150								
H. *vulgare* var. *vulgare* L. (BRI)					23								
H. *vulgare* L. (RI)		5	1	1				1		1	13	346	
H. *vulgare* L. (BRI)												9	
H. cf. *vulgare* L. (RI)													
H. *distichon* L. (RI)											1	18	
H. cf. *distichon* L. (RI)													
A. *sativa* L. (FB)												2	
Cereal/monocotyledon (>2 mm.) (CN)	5	8	1		1299	1				1	2	32	
Cereal/monocotyledon (>2 mm.) (CB)	69	40	1		302	8	18	5	1	8	11	383	3
Total chaff	**75**	**53**	**3**	**1**	**1915**	**9**	**18**	**6**	**1**	**10**	**29**	**842**	**3**

Key to plant parts in Tables 6.4 to 6.6:
Grain
(C) = caryopsis
(S) = seed
Chaff
(AF) = awn fragment
(BRI) = basal rachis internode
(CB) = culm base (greater than 2mm in diameter)
(CN) = culm node (greater than 2mm in diameter)
(FB) = floret base
(RI) = rachis internode
(SLS) = sterile lateral spikelet
Wild
(A) = achene
(C) = caryopsis
(F) = fruit
(Cap) = capsule
(CapB) = capsule base
(CB) = culm base (less than 2mm in diameter)
(CN) = culm node (less than 2mm in diameter)
(FB/Sp) = floret base/spikelet
(LF) = leaf fragment
(N) = nutlet
(NF) = nutshell fragment
(P) = pericarp
(R) = rhizome (greater and less than 2mm in diameter)
(S) = seed

Table 6.4a: Carbonised plant macrofossil total for each block (Quantifiable components: grain and chaff)

Block	BO-E	BO-LIA	LB-LIA	BO-LIA/N	BO-N	GAL-N/M	AD-M	
Period	LIA-I	LIA-II	LIA-II	LIA/N	N/EM	N/EM	N/EM	
Number of samples	1	80	4	26	11	10	3	**Total**
Grain								
Hordeum sp. (C)	4	3311	17	671	353	277	1	**5274**
H. *distichon* var. *vulgare* L. (C)								**4**
H. *vulgare* var. *vulgare* L. asymmetric (C)								**7**
H. *vulgare* var. *vulgare* L. symmetric (C)								**14**
H. naked (C)		13		6				**32**
H. cf. naked (C)		37		28	16			**106**
H. naked symmetric (C)		6		7		6		**29**
H. naked asymmetric (C)		11		8				**27**
H. hulled (C)	2	2555	27	734	273	324		**5268**
H. cf. hulled (C)	1	1167	8	269	119	131	1	**2124**
H. hulled symmetric (C)		1239	12	215	63	136		**2205**
H. hulled asymmetric (C)		2097	27	330	116	217	1	**3684**
Triticum sp. (C)		44	1	10	4	3		**68**
Avena sp. (C)		158	4	110	343	269	50	**962**
A. *sativa* L. (C)		1						**1**
Secale cereale L. (C)		1			3	2		**6**
Linum usitatissimum sp. (S)		1222	32	7	12	1		**1282**
Cereal indeterminate (C)		2760	9	393	231	398	6	**4272**
Total grain	**7**	**14622**	**137**	**2788**	**1533**	**1764**	**59**	**25362**
Chaff								
Cereal indeterminate (AF)								**2**
Hordeum sp. (RI)						3		**75**
H. *distichon* var. *vulgare* L. (RI)								**28**
H. cf. *distichon* var. *vulgare* L. (RI)								**28**
H. *distichon* var. *vulgare* L. (BRI)								**9**
H. *distichon* var. *vulgare* L. (SLS)								**43**
H. *vulgare* var. *vulgare* L. (RI)								**150**
H. *vulgare* var. *vulgare* L. (BRI)								**23**
H. *vulgare* L. (RI)		36		8		12		**424**
H. *vulgare* L. (BRI)		3						**12**
H. cf. *vulgare* L. (RI)		3						**3**
H. *distichon* L. (RI)		2				2		**23**
H. cf. *distichon* L. (RI)				1				**1**
A. *sativa* L. (FB)		2		2	1	1		**8**
Cereal/monocotyledon (>2 mm.) (CN)		23		15		22	5	**1414**
Cereal/monocotyledon (>2 mm.) (CB)		599	7	219	40	15	7	**1736**
Total chaff	**0**	**668**	**7**	**245**	**41**	**55**	**12**	**3993**

Table 6.4b: Carbonised plant macrofossil total for each block (Quantifiable components: grain and chaff continued)

Block	CC-3	GE	DB-P	DB-M	DB-S	AD-IA	GUN-IA	CN-W	CN-C	CN-R	LB-R	LB-C
Period	BA	EIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	LIA-I	LIA-I
Number of samples	12	18	1	1	1	10	12	3	1	4	1	20
Wild plants												
Ajuga reptans L. (S)												
Arctostaphylos uva-ursi (L.) Sprengel (F)							2				1	6
Atriplex hastata L. (S)	3											
Atriplex spp. (S)												
Betula sp. (S)												
Brassica cf. *rapa* L. (S)							1				36	67
Brassica rapa L. (S)	316		1	39	155							
Brassica/Sinapis spp. (S)	129	2				1	9			4	3	21
Brassicaceae undiff. (CapB)					2					1		
Brassicaceae undiff. (S)												1
Calluna vulgaris (L.) Hull. (S)	1											
Calluna vulgaris (L.) Hull. (Cap)	9						5				2	28
Calluna vulgaris (L.) Hull. (LF)	1F				18F		39F			1F	16F	57F
Carex spp. (biconvex) (N)	61	1				3	10			7	6	12
Carex spp. (trigonous) (N)	101	1				13	11			8	11	55
cf. *Vicia/Lathyrus* spp. (S)												
Chenopodium album L. (S)				1								3
Chenopodium/Atriplex spp. (S)	13										1	9
Chrysanthemum segetum L. (A)	1	1										
Corylus avellana L. (NF)		2F										2F
Cyperaceae undiff. (S)												1
Danthonia decumbens L. (C)	30						6			1		2
Eleocharis palustris L. (N)												3
Empetrum nigrum L. (F)						3	2					3
Erica tetralix L. (LF)					4F							2F
Erica/Calluna spp. (Cap)			4		2		4				7	91
Erica/Calluna spp. (LF)					3F							
Fallopia convolvulus L. A. Love (N)												
Fumaria officanalis L. (F)											1	6
Galeopsis tetrahit L. (N)	2										1	
Galium aparine L. (N)												
Hypericum pulchrum L. (S)										4		
Juniperis communis L. (P)											1	
Montia fontana L. (S)	2										1	
Persicaria lapathifolia (L.) Gray (N)	1											1
Persicaria maculosa Gray (N)	1											
Plantago lanceolata L. (S)	40	4				1	3				4	10
Poa cf. *annua* L. (C)	4											
Poaceae undiff. (large) (C)						1	3				1	6
Poaceae undiff. (medium) (C)	13	1	1		3		6			3	3	3
Poaceae undiff. (medium) (FB/Sp)					7	3						
Poaceae undiff. (small) (C)	8					5	3				3	5

Table 6.4c: Carbonised plant macrofossil total for each block (Quantifiable components: wild plants)

Block	GAL-LIA	BO-E	BO-LIA	LB-LIA	BO-LIA/N	BO-N	GAL-N/M	AD-M	
Period	LIA-I	LIA-I	LIA-II	LIA-II	LIA/N	N/EM	N/EM	N/EM	
Number of samples	2	1	80	4	26	11	10	3	**Total**
Wild plants									
Ajuga reptans L. (S)			1						**1**
Arctostaphylos uva-ursi (L.) Sprengel (F)			5			2			**16**
Atriplex hastata L. (S)							2		**5**
Atriplex spp. (S)							2		**2**
Betula sp. (S)							1		**1**
Brassica cf. *rapa* L. (S)			38		8	2	26		**178**
Brassica rapa L. (S)			85						**596**
Brassica/Sinapis spp. (S)				1	8	3	3		**184**
Brassicaceae undiff. (CapB)									**3**
Brassicaceae undiff. (S)									**1**
Calluna vulgaris (L.) Hull. (S)									**1**
Calluna vulgaris (L.) Hull. (Cap)			4	5	2				**55**
Calluna vulgaris (L.) Hull. (LF)			51F		13F				**0**
Carex spp. (biconvex) (N)			49	1	8		16		**174**
Carex spp. (trigonous) (N)			81	1	27	3	20	1	**333**
cf. *Vicia/Lathyrus* spp. (S)									**0**
Chenopodium album L. (S)			34		5	2	5		**50**
Chenopodium/Atriplex spp. (S)			24		1	2	8		**58**
Chrysanthemum segetum L. (A)									**2**
Corylus avellana L. (NF)			4F						**0**
Cyperaceae undiff. (S)									**1**
Danthonia decumbens L. (C)			12		8	1	12	3	**75**
Eleocharis palustris L. (N)			50		5			1	**59**
Empetrum nigrum L. (F)			6		2	1			**17**
Erica tetralix L. (LF)			9F						**0**
Erica/Calluna spp. (Cap)			12		3		1		**124**
Erica/Calluna spp. (LF)									**0**
Fallopia convolvulus L. A. Love (N)			2		1				**3**
Fumaria officanalis L. (F)			2						**9**
Galeopsis tetrahit L. (N)			4						**7**
Galium aparine L. (N)			2			2			**4**
Hypericum pulchrum L. (S)									**4**
Juniperis communis L. (P)									**1**
Montia fontana L. (S)			4				3		**10**
Persicaria lapathifolia (L.) Gray (N)			24						**26**
Persicaria maculosa Gray (N)			2	3					**6**
Plantago lanceolata L. (S)			29		6	2	2	1	**102**
Poa cf. *annua* L. (C)			1						**5**
Poaceae undiff. (large) (C)			95		7	7	9	2	**131**
Poaceae undiff. (medium) (C)			218	2	11	6	16		**286**
Poaceae undiff. (medium) (FB/Sp)									**10**
Poaceae undiff. (small) (C)			32		6	1	6		**69**

Table 6.4d: Carbonised plant macrofossil total for each block (Quantifiable components: wild plants continued)

Block	CC-3	GE	DB-P	DB-M	DB-S	AD-IA	GUN-IA	CN-W	CN-C	CN-R	LB-R	LB-C
Period	BA	EIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	LIA-I	LIA-I
Number of samples	12	18	1	1	1	10	12	3	1	4	1	20
Polygonum aviculare L. (N)	7	1					1					4
Polygonum cf. *aviculare* L. (N)					8							
Polygonum cf. *oxyspermum* (M. & B. ex Lb.) (N)					2							
Polygonum spp. (N)	18			2	3	3				1	3	4
Potentilla erecta (L.) Raeusch (S)											1	
Potentilla sp. (S)												2
Pteridium aquilinium (L.) Kuhn (LF)												
Ranunculus acris L. (A)												
Ranunculus bulbosus L. (A)												
Ranunculus cf. *bulbosus* L. (A)					1							
Ranunculus cf. *repens* L. (A)					1							
Ranunculus repens L. (A)	9											1
Ranunculus spp. (A)	8											2
Raphanus raphanistrum L. (F)	3											
Rumex acetosa L. (N)	1										1	
Rumex acetosella L. (N)	35	1				1	2					1
Rumex cf. *crispus* L. (N)	40											
Rumex crispus L. (N)						2	14			5	7	22
Rumex spp. (N)	6					2	2				2	12
Sinapis arvensis L. (S)												1
Sorbus aucuparia L. (S)		1										
Sorbus sp. (S)	1											1
Spergula arvensis L. (S)	6						1					
Stachys cf. *palustris* L. (F)	14											
Stachys spp. (F)	1											
Stellaria media (L.) Villars (S)	34		2	1	1	2	10				16	4
Trifolium repens L. (S)												
Trifolium sp. (S)											1	
Urtica dioica L. (F)	1											
Urtica urens L. (F)	1											
Vaccinium myrtillus L. (S)	3					2	1					1
Vaccinium vitis-idaea L. (S)	4						1					
Vicia sativa L. (S)												
Vicia/Lathyrus spp. (S)	1					1						
Viola sp. (S)					7		1			1	1	1
Cereal/monocotyledon (<2 mm.) (CN)	121	5	1		109	3	19			1	1	20
Cereal/monocotyledon (<2 mm.) (CB)	178	42			169	24	53	2		18	4	300
Indeterminate (>2 mm.) (R)	33	58				8	156	1		2	2	38
Indeterminate (<2 mm.) (R)	96	26			4	49	271			1	5	33
Indeterminate (trigonous) (S/F)							2				3	
Indeterminate pericarp fragment (P)	1						2					1
Indeterminate seed/fruit (S/F)	62	5			10	42	23		1	7	18	42
Moss fragments (carbonised) (LF)												
Seaweed (LF)												1F
Total wild	**1438**	**149**	**9**	**43**	**484**	**169**	**624**	**3**	**1**	**65**	**147**	**823**
Total QC	**1952**	**584**	**63**	**44**	**2819**	**255**	**698**	**108**	**13**	**106**	**238**	**4459**

Table 6.4e: Carbonised plant macrofossil total for each block (Quantifiable components: wild plants continued)

Block	GAL-LIA	BO-E	BO-LIA	LB-LIA	BO-LIA/N	BO-N	GAL-N/M	AD-M	
Period	LIA-I	LIA-I	LIA-II	LIA-II	LIA/N	N/EM	N/EM	N/EM	
Number of samples	2	1	80	4	26	11	10	3	**Total**
Polygonum aviculare L. (N)			11		10	4			**38**
Polygonum cf. *aviculare* L. (N)								3	**11**
Polygonum cf. *oxyspermum* (M. & B. ex Lb.) (N)									**2**
Polygonum spp. (N)	1		49	2	15	4	3	1	**109**
Potentilla erecta (L.) Raeusch (S)					1				**2**
Potentilla sp. (S)									**2**
Pteridium aquilinium (L.) Kuhn (LF)			9F						**0**
Ranunculus acris L. (A)							1		**1**
Ranunculus bulbosus L. (A)			1		1	1	1		**4**
Ranunculus cf. *bulbosus* L. (A)									**1**
Ranunculus cf. *repens* L. (A)									**1**
Ranunculus repens L. (A)			5		2	1			**18**
Ranunculus spp. (A)			6		1	1		1	**19**
Raphanus raphanistrum L. (F)			1		1				**5**
Rumex acetosa L. (N)			3	1	5				**11**
Rumex acetosella L. (N)			34	1	9	1	3		**88**
Rumex cf. *crispus* L. (N)									**40**
Rumex crispus L. (N)		1	174	1	115	16	15		**372**
Rumex spp. (N)		1	44		14	2	5		**90**
Sinapis arvensis L. (S)									**1**
Sorbus aucuparia L. (S)									**1**
Sorbus sp. (S)									**2**
Spergula arvensis L. (S)			169	2	3	12	2		**195**
Stachys cf. *palustris* L. (F)			6						**20**
Stachys spp. (F)									**1**
Stellaria media (L.) Villars (S)			18	1	5		12		**106**
Trifolium repens L. (S)			5						**5**
Trifolium sp. (S)									**1**
Urtica dioica L. (F)			44				1		**46**
Urtica urens L. (F)									**1**
Vaccinium myrtillus L. (S)						1			**8**
Vaccinium vitis-idaea L. (S)									**5**
Vicia sativa L. (S)						1			**1**
Vicia/Lathyrus spp. (S)					1				**3**
Viola sp. (S)			6		2				**19**
Cereal/monocotyledon (<2 mm.) (CN)	2		184		87	3	11	2	**569**
Cereal/monocotyledon (<2 mm.) (CB)	1	1	601	4	392	15	28	21	**1853**
Indeterminate (>2 mm.) (R)	1		74	2	109	18	9	21	**532**
Indeterminate (<2 mm.) (R)	11		26		25	4	30	45	**626**
Indeterminate (trigonous) (S/F)			68		22	6	41		**142**
Indeterminate pericarp fragment (P)			13		2				**19**
Indeterminate seed/fruit (S/F)	1		295	10	58	28	16	10	**628**
Moss fragments (carbonised) (LF)			1F						**0**
Seaweed (LF)			1010+F		2F	1F			**0**
Total wild	**18**	**3**	**2658**	**37**	**988**	**152**	**310**	**112**	**8233**
Total QC	**54**	**10**	**17948**	**181**	**4021**	**1726**	**2129**	**183**	**37591**

Table 6.4f: Carbonised plant macrofossil total for each block (Quantifiable components: wild plants continued)

Block	CC-3	GE	DB-P	DB-M	DB-S	AD-IA	GUN-IA	CN-W	CN-C	CN-R	LB-R	LB-C	GAL-LIA
Period	BA	EIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	LIA-I	LIA-I	LIA-I
Number of samples	12	18	1	1	1	10	12	3	1	4	1	20	2
Grain													
Hordeum sp. (C)	32.8	31.7	21.6			7.8	8.9	11.1		16.1	8.1	11.6	27.3
H. *distichon* var. *vulgare* L. (C)					1								
H. *vulgare* var. *vulgare* L. asymmetric (C)					1.7								
H. *vulgare* var. *vulgare* L. symmetric (C)					3.3								
H. naked (C)	2.1	0.8	2										
H. cf. naked (C)	3.9	1.8	2										
H. naked symmetric (C)	1.1		17.6									0.1	12.1
H. naked asymmetric (C)	1.4	0.3	11.8									0.1	
H. hulled (C)	19.4	26.2			18.3	42.9	26.8	30.3	36.4	29	41.9	34.4	12.1
H. cf. hulled (C)	6.4	14.7				18.2	1.8	15.2	54.5	9.7	19.4	10.3	
H. hulled symmetric (C)	2.7	3.4			31.7	7.8	7.1	10.1		6.5	8.1	12.7	
H. hulled asymmetric (C)	5.5	4.5			44	10.4	10.7	23.2	9.1	22.6	11.3	21.9	21.2
Triticum sp. (C)	0.5											0.1	
Avena sp. (C)	0.9					1.3	33.9				1.6	0.1	
A. *sativa* L. (C)													
Secale cereale L. (C)													
Linum usitatissimum sp. (S)						1.3					3.2	0.2	
Cereal indeterminate (C)	23.5	16.8	45.1			10.4	10.7	10.1		16.1	6.5	8.7	27.3
Grain as % of total QC	**22.5**	**65.4**	**81**	**0**	**14.9**	**30.2**	**8**	**91.7**	**84.6**	**29.3**	**26.1**	**62.7**	**61.1**
Chaff													
Cereal indeterminate (AF)	1.3											0.1	
Hordeum sp. (RI)					1.8						6.9	1.1	
H. *distichon* var. *vulgare* L. (RI)					1.5								
H. cf. *distichon* var. *vulgare* L. (RI)					1.5								
H. *distichon* var. *vulgare* L. (BRI)					0.5								
H. *distichon* var. *vulgare* L. (SLS)					2.2							0.1	
H. *vulgare* var. *vulgare* L. (RI)					7.8								
H. *vulgare* var. *vulgare* L. (BRI)					1.2								
H. *vulgare* L. (RI)		9.4	33.3	100				16.7		10	44.8	41.1	
H. *vulgare* L. (BRI)												1.1	
H. cf. *vulgare* L. (RI)													
H. *distichon* L. (RI)											3.4	2.1	
H. cf. *distichon* L. (RI)													
A. *sativa* L. (FB)												0.2	
Cereal/monocotyledon (>2 mm.) (CN)	6.7	15.1	33.3		67.8	11.1				10	6.9	3.8	
Cereal/monocotyledon (>2 mm.) (CB)	92	75.5	33.3		15.8	88.9	100	83.3	100	80	37.9	45.5	100
Chaff as % of total QC	**3.8**	**9.1**	**4.8**	**2.3**	**67.9**	**3.5**	**2.6**	**5.6**	**7.7**	**9.4**	**12.2**	**18.9**	**5.6**

Table 6.5a: Carbonised plant macrofossil total for each block (Proportion by class: grain and chaff)

Block	BO-E	BO-LIA	LB-LIA	BO-LIA/N	BO-N	GAL-N/M	AD-M
Period	LIA-I	LIA-II	LIA-II	LIA/N	N/EM	N/EM	N/EM
Number of samples	1	80	4	26	11	10	3
Grain							
Hordeum sp. (C)	57.1	22.6	12.4	24.1	23	15.7	1.7
H. *distichon* var. *vulgare* L. (C)							
H. *vulgare* var. *vulgare* L. asymmetric (C)							
H. *vulgare* var. *vulgare* L. symmetric (C)							
H. naked (C)		0.1		0.2			
H. cf. naked (C)		0.3		1	1		
H. naked symmetric (C)		0.1		0.3		0.3	
H. naked asymmetric (C)		0.1		0.3			
H. hulled (C)	28.6	17.5	19.7	26.3	17.8	18.4	
H. cf. hulled (C)	14.3	8	5.8	9.6	7.8	7.4	1.7
H. hulled symmetric (C)		8.5	8.8	7.7	4.1	7.7	
H. hulled asymmetric (C)		14.3	19.7	11.8	7.6	12.3	1.7
Triticum sp. (C)		0.3	0.7	0.4	0.3	0.2	
Avena sp. (C)		1.1	2.9	3.9	22.4	15.2	84.7
A. *sativa* L. (C)		0.1					
Secale cereale L. (C)		0.1			0.2	0.1	
Linum usitatissimum sp. (S)		8.4	23.4	0.3	0.8	0.1	
Cereal indeterminate (C)		18.9	6.6	14.1	15.1	22.6	10.2
Grain as % of total QC	**70**	**81.5**	**75.7**	**69.3**	**88.8**	**82.9**	**32.2**
Chaff							
Cereal indeterminate (AF)							
Hordeum sp. (RI)						5.5	
H. *distichon* var. *vulgare* L. (RI)							
H. cf. *distichon* var. *vulgare* L. (RI)							
H. *distichon* var. *vulgare* L. (BRI)							
H. *distichon* var. *vulgare* L. (SLS)							
H. *vulgare* var. *vulgare* L. (RI)							
H. *vulgare* var. *vulgare* L. (BRI)							
H. *vulgare* L. (RI)		5.4		3.3		21.8	
H. *vulgare* L. (BRI)		0.4					
H. cf. *vulgare* L. (RI)		0.4					
H. *distichon* L. (RI)		0.3				3.6	
H. cf. *distichon* L. (RI)				0.4			
A. *sativa* L. (FB)		0.3		0.8	2.4	1.8	
Cereal/monocotyledon (>2 mm.) (CN)		3.4		6.1		40	41.7
Cereal/monocotyledon (>2 mm.) (CB)		89.7	100	89.4	97.6	27.3	58.3
Chaff as % of total QC	**0**	**3.7**	**3.9**	**6.1**	**2.4**	**2.5**	**6.6**

Table 6.5b: Carbonised plant macrofossil total for each block (Proportion by class: grain and chaff continued)

Block	CC-3	GE	DB-P	DB-M	DB-S	AD-IA	GUN-IA	CN-W	CN-C	CN-R	LB-R	LB-C
Period	BA	EIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	LIA-I	LIA-I
Number of samples	12	18	1	1	1	10	12	3	1	4	1	20
Wild plants												
Ajuga reptans L. (S)												
Arctostaphylos uva-ursi (L.) Sprengel (F)							0.3				0.7	0.7
Atriplex hastata L. (S)	0.2											
Atriplex spp. (S)												
Betula sp. (S)												
Brassica cf. *rapa* L. (S)					32		0.2				24.5	8.1
Brassica rapa L. (S)	22		11.1	90.7								
Brassica/Sinapis spp. (S)	9	1.3				0.6	1.4			6.2	2	2.6
Brassicaceae undiff. (CapB)					0.4					1.5		
Brassicaceae undiff. (S)												0.1
Calluna vulgaris (L.) Hull. (S)	0.1											
Calluna vulgaris (L.) Hull. (Cap)	0.6						0.8				1.4	3.4
Calluna vulgaris (L.) Hull. (LF)												
Carex spp. (biconvex) (N)	4.2	0.7				1.8	1.6			10.8	4.1	1.5
Carex spp. (trigonous) (N)	7	0.7				7.7	1.8			12.3	7.5	6.7
cf. *Vicia/Lathyrus* spp. (S)												
Chenopodium album L. (S)												0.4
Chenopodium/Atriplex spp. (S)	0.9										0.7	1.1
Chrysanthemum segetum L. (A)	0.1	0.7										
Corylus avellana L. (NF)												
Cyperaceae undiff. (S)												0.1
Danthonia decumbens L. (C)	2.1						1			1.5		0.2
Eleocharis palustris L. (N)												0.4
Empetrum nigrum L. (F)						1.8	0.3					0.4
Erica tetralix L. (LF)												
Erica/Calluna spp. (Cap)	1.3		44.4		0.4		0.6				4.8	11.1
Erica/Calluna spp. (LF)												
Fallopia convolvulus L. A. Love (N)												
Fumaria officanalis L. (F)											0.7	0.7
Galeopsis tetrahit L. (N)	0.1										0.7	
Galium aparine L. (N)												
Hypericum pulchrum L. (S)										6.2		
Juniperis communis L. (P)											0.7	
Montia fontana L. (S)	0.1										0.7	
Persicaria lapathifolia (L.) Gray (N)	0.1											0.1
Persicaria maculosa Gray (N)	0.1											
Plantago lanceolata L. (S)	2.8	2.7				0.6	0.5				2.7	1.2
Poa cf. *annua* L. (C)	0.3											
Poaceae undiff. (large) (C)						0.6	0.5				0.7	0.6
Poaceae undiff. (medium) (C)	0.9	0.7	11.1		0.6		1			4.6	2	0.4
Poaceae undiff. (medium) (FB/Sp)					1.4	1.8						
Poaceae undiff. (small) (C)	0.6					3	0.5				2	0.6

Table 6.5c: Carbonised plant macrofossil total for each block (Proportion by class: wild plants)

Block	GAL-LIA	BO-E	BO-LIA	LB-LIA	BO-LIA/N	BO-N	GAL-N/M	AD-M
Period	LIA-I	LIA-I	LIA-II	LIA-II	LIA/N	N/EM	N/EM	N/EM
Number of samples	2	1	80	4	26	11	10	3
Wild plants								
Ajuga reptans L. (S)			0.1					
Arctostaphylos uva-ursi (L.) Sprengel (F)			0.2			1.3		
Atriplex hastata L. (S)							0.6	
Atriplex spp. (S)							0.6	
Betula sp. (S)							0.3	
Brassica cf. *rapa* L. (S)			1.4		0.8	1.3	8.4	
Brassica rapa L. (S)			3.2					
Brassica/Sinapis spp. (S)				2.7	0.8	2	1	
Brassicaceae undiff. (CapB)								
Brassicaceae undiff. (S)								
Calluna vulgaris (L.) Hull. (S)								
Calluna vulgaris (L.) Hull. (Cap)			0.2	13.5	0.2			
Calluna vulgaris (L.) Hull. (LF)								
Carex spp. (biconvex) (N)			1.8	2.7	0.8		5.2	
Carex spp. (trigonous) (N)			3	2.7	2.7	2	6.5	0.99
cf. *Vicia/Lathyrus* spp. (S)								
Chenopodium album L. (S)			1.3		0.5	1.3	1.6	
Chenopodium/Atriplex spp. (S)			0.9		0.1	1.3	2.6	
Chrysanthemum segetum L. (A)								
Corylus avellana L. (NF)								
Cyperaceae undiff. (S)								
Danthonia decumbens L. (C)			0.5		0.8	0.7	3.9	2.7
Eleocharis palustris L. (N)			1.9		0.5			0.9
Empetrum nigrum L. (F)			0.2		0.2	0.7		
Erica tetralix L. (LF)								
Erica/Calluna spp. (Cap)			0.5		0.3		0.3	
Erica/Calluna spp. (LF)								
Fallopia convolvulus L. A. Love (N)			0.1		0.1			
Fumaria officanalis L. (F)			0.1					
Galeopsis tetrahit L. (N)			0.2					
Galium aparine L. (N)			0.1			1.3		
Hypericum pulchrum L. (S)								
Juniperis communis L. (P)								
Montia fontana L. (S)			0.2				1	
Persicaria lapathifolia (L.) Gray (N)			0.9					
Persicaria maculosa Gray (N)			0.1	8.1				
Plantago lanceolata L. (S)			1.1		0.6	1.3	0.6	0.9
Poa cf. *annua* L. (C)			0.1					
Poaceae undiff. (large) (C)			3.6		0.7	4.6	2.9	1.8
Poaceae undiff. (medium) (C)			8.2	5.4	1.1	3.9	5.2	
Poaceae undiff. (medium) (FB/Sp)								
Poaceae undiff. (small) (C)			1.2		0.6	0.7	1.9	

Table 6.5d: Carbonised plant macrofossil total for each block (Proportion by class: wild plants continued)

Block	CC-3	GE	DB-P	DB-M	DB-S	AD-IA	GUN-IA	CN-W	CN-C	CN-R	LB-R	LB-C
Period	BA	EIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	LIA-I	LIA-I
Number of samples	12	18	1	1	1	10	12	3	1	4	1	20
Polygonum aviculare L. (N)	0.5	0.7					1					0.5
Polygonum cf. *aviculare* L. (N)					1.7							
Polygonum cf. *oxyspermum* (M. & B. ex Lb.) (N)					0.4							
Polygonum spp. (N)	1.3			4.7	0.6	1.8				1.5	2	0.5
Potentilla erecta (L.) Raeusch (S)											0.7	
Potentilla sp. (S)												0.2
Pteridium aquilinium (L.) Kuhn (LF)												
Ranunculus acris L. (A)												
Ranunculus bulbosus L. (A)												
Ranunculus cf. *bulbosus* L. (A)					0.2							
Ranunculus cf. *repens* L. (A)	0.6											
Ranunculus repens L. (A)					0.2							0.1
Ranunculus spp. (A)	0.6											0.2
Raphanus raphanistrum L. (F)	0.2											
Rumex acetosa L. (N)	0.1										0.7	
Rumex acetosella L. (N)	2.4	0.7				0.6	0.3					0.1
Rumex cf. *crispus* L. (N)												
Rumex crispus L. (N)	2.8					1.2	2.2			7.7	4.8	2.7
Rumex spp. (N)	0.4					1.2	0.3				1.4	1.5
Sinapis arvensis L. (S)												0.1
Sorbus aucuparia L. (S)		0.7										
Sorbus sp. (S)	0.1											0.1
Spergula arvensis L. (S)	0.4						0.2					
Stachys cf. *palustris* L. (F)	1											
Stachys spp. (F)	0.1											
Stellaria media (L.) Villars (S)	2.4		22.2	2.3	0.2	1.2	1.6				10.9	0.5
Trifolium repens L. (S)												
Trifolium sp. (S)											0.7	
Urtica dioica L. (F)	0.1											
Urtica urens L. (F)	0.1											
Vaccinium myrtillus L. (S)	0.2					1.2	0.2					0.1
Vaccinium vitis-idaea L. (S)	0.3						0.2					
Vicia sativa L. (S)												
Vicia/Lathyrus spp. (S)	0.1					0.6						
Viola sp. (S)					1.4		0.2			1.5	0.7	0.1
Cereal/monocotyledon (<2 mm.) (CN)	8.4	3.4	11.1		22.5	1.8	3			1.5	0.7	2.4
Cereal/monocotyledon (<2 mm.) (CB)	12.4	28.2			34.9	14.2	8.5	66.7		27.7	2.7	36.5
Indeterminate (>2 mm.) (R)	2.3	38.9				4.7	25	33.3		3.1	1.4	4.6
Indeterminate (<2 mm.) (R)	6.7	17.4			0.8	29	43.4			1.5	3.4	4
Indeterminate (trigonous) (S/F)							0.3				2	
Indeterminate pericarp fragment (P)	0.1						0.3					0.1
Indeterminate seed/fruit (S/F)	4.3	3.4			2.1	24.9	3.7		100	10.8	12.2	5.1
Moss fragments (carbonised) (LF)												
Seaweed (LF)												
Wild plants as % of total QC	**73.7**	**25.5**	**14.3**	**97.7**	**17.2**	**66.3**	**89.4**	**2.8**	**7.7**	**61.3**	**61.8**	**18.4**

Table 6.5e: Carbonised plant macrofossil total for each block (Proportion by class: wild plants continued)

Block	GAL-LIA	BO-E	BO-LIA	LB-LIA	BO-LIA/N	BO-N	GAL-N/M	AD-M
Period	LIA-I	LIA-I	LIA-II	LIA-II	LIA/N	N/EM	N/EM	N/EM
Number of samples	2	1	80	4	26	11	10	3
Polygonum aviculare L. (N)			0.4		1	2.6		
Polygonum cf. *aviculare* L. (N)								2.7
Polygonum cf. *oxyspermum* (M. & B. ex Lb.) (N)								
Polygonum spp. (N)	5.6		1.8	5.4	1.5	2.6	1	0.9
Potentilla erecta (L.) Raeusch (S)					0.1			
Potentilla sp. (S)								
Pteridium aquilinium (L.) Kuhn (LF)								
Ranunculus acris L. (A)							0.3	
Ranunculus bulbosus L. (A)			0.1		0.1	0.7	0.3	
Ranunculus cf. *bulbosus* L. (A)								
Ranunculus cf. *repens* L. (A)								
Ranunculus repens L. (A)			0.2		0.2	0.7		
Ranunculus spp. (A)			0.2		0.1	0.7		0.9
Raphanus raphanistrum L. (F)			0.1		0.1			
Rumex acetosa L. (N)			0.1	2.7	0.5			
Rumex acetosella L. (N)			1.3	2.7	0.9	0.7	1	
Rumex cf. *crispus* L. (N)								
Rumex crispus L. (N)		33.3	6.5	2.7	11.6	10.5	4.8	
Rumex spp. (N)		33.3	1.7		1.4	1.3	1.6	
Sinapis arvensis L. (S)								
Sorbus aucuparia L. (S)								
Sorbus sp. (S)								
Spergula arvensis L. (S)			6.4	5.4	0.3	7.9	0.6	
Stachys cf. *palustris* L. (F)			0.2					
Stachys spp. (F)								
Stellaria media (L.) Villars (S)			0.7	2.7	0.5		3.9	
Trifolium repens L. (S)			0.2					
Trifolium sp. (S)								
Urtica dioica L. (F)			1.7				0.3	
Urtica urens L. (F)								
Vaccinium myrtillus L. (S)						0.7		
Vaccinium vitis-idaea L. (S)								
Vicia sativa L. (S)						0.7		
Vicia/Lathyrus spp. (S)					0.1			
Viola sp. (S)			0.2		0.2			
Cereal/monocotyledon (<2 mm.) (CN)	11.1		6.9		8.8	2	3.5	1.8
Cereal/monocotyledon (<2 mm.) (CB)	5.6	33.3	22.6	10.8	39.7	9.9	9	18.8
Indeterminate (>2 mm.) (R)	5.6		2.8	5.4	11	11.8	2.9	18.8
Indeterminate (<2 mm.) (R)	61.1		1		2.5	2.6	9.7	40.2
Indeterminate (trigonous) (S/F)			2.6		2.2	3.9	13.2	
Indeterminate pericarp fragment (P)			0.5		2			
Indeterminate seed/fruit (S/F)	5.6		11.1	27	5.8	18.4	5.2	8.9
Moss fragments (carbonised) (LF)								
Seaweed (LF)								
Wild plants as % of total QC	**33.3**	**30**	**14.8**	**20.4**	**24.6**	**8.8**	**14.6**	**61.2**

Table 6.5f: Carbonised plant macrofossil total for each block (Proportion by class: wild plants continued)

Block	CC-3	GE	DB-P	DB-M	DB-S	AD-IA	GUN-IA	CN-W	CN-C	CN-R	LB-R	LB-C	GAL-LIA
Period	BA	EIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	LIA-I	LIA-I	LIA-I
Number of samples	12	18	1	1	1	10	12	3	1	4	1	20	2
Grain													
Hordeum sp. (C)	92	89	100			20	33.3	100		75	100	85	100
H. *distichon* var. *vulgare* L. (C)					100								
H. *vulgare* var. *vulgare* L. asymmetric (C)					100								
H. *vulgare* var. *vulgare* L. symmetric (C)					100								
H. naked (C)	58	17	100										
H. cf. naked (C)	42	39	100										
H. naked symmetric (C)	33											5	50
H. naked asymmetric (C)	25	7										5	
H. hulled (C)	58	89	100		100	50	41.7	100	100	50	100	100	100
H. cf. hulled (C)	42	89	100			20	8.3	66.7	100	25	100	75	
H. hulled symmetric (C)	42	56			100	40	25	100		50	100	85	
H. hulled asymmetric (C)	50	61			100	50	33.3	66.7	100	75	100	90	50
Triticum sp. (C)	17											5	
Avena sp. (C)	17					10	33.3				100	15	
A. *sativa* L. (C)													
Secale cereale L. (C)													
Linum usitatissimum sp. (S)						10					100	10	
Cereal indeterminate (C)	92	72	100			30	41.7	100		50	100	55	50
Chaff													
Cereal indeterminate (AF)	8											5	
Hordeum sp. (RI)					100						100	10	
H. *distichon* var. *vulgare* L. (RI)					100								
H. cf. *distichon* var. *vulgare* L. (RI)					100								
H. *distichon* var. *vulgare* L. (BRI)					100								
H. *distichon* var. *vulgare* L. (SLS)					100							5	
H. *vulgare* var. *vulgare* L. (RI)					100								
H. *vulgare* var. *vulgare* L. (BRI)					100								
H. *vulgare* L. (RI)		17	100	100				33.3		25	100	50	
H. *vulgare* L. (BRI)												10	
H. cf. *vulgare* L. (RI)													
H. *distichon* L. (RI)											100	30	
H. cf. *distichon* L. (RI)													
A. *sativa* L. (FB)												5	
Cereal/monocotyledon (>2 mm.) (CN)	17	28	100		100	10				25	100	60	
Cereal/monocotyledon (>2 mm.) (CB)	83	67	100		100	60	58.3	66.7	100	75	100	90	50

Table 6.6a: Carbonised plant macrofossil total for each block (Ubiquity scores: grain and chaff)

Block	BO-E	BO-LIA	LB-LIA	BO-LIA/N	BO-N	GAL-N/M	AD-M
Period	LIA-I	LIA-II	LIA-II	LIA/N	N/EM	N/EM	N/EM
Number of samples	1	80	4	26	11	10	3
Grain							
Hordeum sp. (C)	100	93	100	85	90.9	80	33.3
H. *distichon* var. *vulgare* L. (C)							
H. *vulgare* var. *vulgare* L. asymmetric (C)							
H. *vulgare* var. *vulgare* L. symmetric (C)							
H. naked (C)		11		12			
H. cf. naked (C)		16		27	54.5		
H. naked symmetric (C)		5		15		20	
H. naked asymmetric (C)		9		8			
H. hulled (C)	100	88	75	96	100	60	
H. cf. hulled (C)	100	80	25	88	72.7	60	33.3
H. hulled symmetric (C)		75	50	81	54.5	60	
H. hulled asymmetric (C)		79	75	77	72.7	40	33.3
Triticum sp. (C)		16	25	19	18.2	30	
Avena sp. (C)		43	25	42	72.7	80	66.7
A. *sativa* L. (C)		1					
Secale cereale L. (C)		1			18.2	10	
Linum usitatissimum sp. (S)		39	50	15	36.4	10	
Cereal indeterminate (C)		83	50	85	72.7	90	33.3
Chaff							
Cereal indeterminate (AF)							
Hordeum sp. (RI)						20	
H. *distichon* var. *vulgare* L. (RI)							
H. cf. *distichon* var. *vulgare* L. (RI)							
H. *distichon* var. *vulgare* L. (BRI)							
H. *distichon* var. *vulgare* L. (SLS)							
H. *vulgare* var. *vulgare* L. (RI)							
H. *vulgare* var. *vulgare* L. (BRI)							
H. *vulgare* L. (RI)		15		12		30	
H. *vulgare* L. (BRI)		4					
H. cf. *vulgare* L. (RI)		4					
H. *distichon* L. (RI)		1				10	
H. cf. *distichon* L. (RI)				4			
A. *sativa* L. (FB)		3		4	9.1	10	
Cereal/monocotyledon (>2 mm.) (CN)		14		38		30	66.7
Cereal/monocotyledon (>2 mm.) (CB)		63	75	69	63.6	10	66.7

Table 6.6b: Carbonised plant macrofossil total for each block (Ubiquity scores: grain and chaff continued)

Block	CC-3	GE	DB-P	DB-M	DB-S	AD-IA	GUN-IA	CN-W	CN-C	CN-R	LB-R	LB-C
Period	BA	EIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	LIA-I	LIA-I
Number of samples	12	18	1	1	1	10	12	3	1	4	1	20
Wild plants												
Ajuga reptans L. (S)												
Arctostaphylos uva-ursi (L.) Sprengel (F)							16.7				100	10
Atriplex hastata L. (S)	8											
Atriplex spp. (S)												
Betula sp. (S)												
Brassica cf. *rapa* L. (S)							8.3				100	55
Brassica rapa L. (S)	100		100	100	100							
Brassica/Sinapis spp. (S)	92	11				10	41.7			25	100	45
Brassicaceae undiff. (CapB)					100					25		
Brassicaceae undiff. (S)												5
Calluna vulgaris (L.) Hull. (S)	8											
Calluna vulgaris (L.) Hull. (Cap)	50						16.7				100	35
Calluna vulgaris (L.) Hull. (LF)	8				100		16.7					35
Carex spp. (biconvex) (N)	75	6				20	41.7			25	100	45
Carex spp. (trigonous) (N)	100	6				40	41.7			25	100	60
cf. *Vicia/Lathyrus* spp. (S)												
Chenopodium album L. (S)				100								5
Chenopodium/Atriplex spp. (S)	67										100	15
Chrysanthemum segetum L. (A)	8											
Corylus avellana L. (NF)		11										10
Cyperaceae undiff. (S)												5
Danthonia decumbens L. (C)	75						41.7			25		10
Eleocharis palustris L. (N)												15
Empetrum nigrum L. (F)						10	16.7					10
Erica tetralix L. (LF)					100							10
Erica/Calluna spp. (Cap)	67		100		100		25				100	50
Erica/Calluna spp. (LF)					100							
Fallopia convolvulus L. A. Love (N)												
Fumaria officanalis L. (F)											100	20
Galeopsis tetrahit L. (N)	17										100	
Galium aparine L. (N)												
Hypericum pulchrum L. (S)										25		
Juniperis communis L. (P)											100	
Montia fontana L. (S)	8										100	
Persicaria lapathifolia (L.) Gray (N)	8											5
Persicaria maculosa Gray (N)	8											
Plantago lanceolata L. (S)	100	6				10	25				100	20
Poa cf. *annua* L. (C)	17											
Poaceae undiff. (large) (C)						10	16.7				100	10
Poaceae undiff. (medium) (C)	67	6	100		100		8.3			50	100	15
Poaceae undiff. (medium) (FB/Sp)					100	20						
Poaceae undiff. (small) (C)	42					30	16.7				100	15

Table 6.6c: Carbonised plant macrofossil total for each block (Ubiquity scores: wild plants)

Block	GAL-LIA	BO-E	BO-LIA	LB-LIA	BO-LIA/N	BO-N	GAL-N/M	AD-M
Period	LIA-I	LIA-I	LIA-II	LIA-II	LIA/N	N/EM	N/EM	N/EM
Number of samples	2	1	80	4	26	11	10	3
Wild plants								
Ajuga reptans L. (S)			1					
Arctostaphylos uva-ursi (L.) Sprengel (F)			3			18.2		
Atriplex hastata L. (S)							10	
Atriplex spp. (S)							10	
Betula sp. (S)							10	
Brassica cf. *rapa* L. (S)			23		19	18.2	10	
Brassica rapa L. (S)			41					
Brassica/Sinapis spp. (S)				25	15	18.2	20	
Brassicaceae undiff. (CapB)								
Brassicaceae undiff. (S)								
Calluna vulgaris (L.) Hull. (S)								
Calluna vulgaris (L.) Hull. (Cap)			4	25	8			
Calluna vulgaris (L.) Hull. (LF)			15		19			
Carex spp. (biconvex) (N)			20	25	8		30	
Carex spp. (trigonous) (N)			38	25	23	18.2	20	33.3
cf. *Vicia/Lathyrus* spp. (S)								
Chenopodium album L. (S)			20		12	18.2	20	
Chenopodium/Atriplex spp. (S)			9		4	18.2	40	
Chrysanthemum segetum L. (A)								
Corylus avellana L. (NF)			4					
Cyperaceae undiff. (S)								
Danthonia decumbens L. (C)			11		15	9.1	20	33.3
Eleocharis palustris L. (N)			31		8			33.3
Empetrum nigrum L. (F)			5		8	9.1		
Erica tetralix L. (LF)			3					
Erica/Calluna spp. (Cap)			11		8		10	
Erica/Calluna spp. (LF)								
Fallopia convolvulus L. A. Love (N)			3		4			
Fumaria officanalis L. (F)			5					
Galeopsis tetrahit L. (N)			5					
Galium aparine L. (N)			3			18.2		
Hypericum pulchrum L. (S)								
Juniperis communis L. (P)								
Montia fontana L. (S)			4				10	
Persicaria lapathifolia (L.) Gray (N)			10					
Persicaria maculosa Gray (N)			3	50				
Plantago lanceolata L. (S)			19		12	18.2	10	33.3
Poa cf. *annua* L. (C)			1					
Poaceae undiff. (large) (C)			31		15	36.4	10	66.7
Poaceae undiff. (medium) (C)			41	25	35	27.3	30	
Poaceae undiff. (medium) (FB/Sp)								
Poaceae undiff. (small) (C)			19		19	9.1	50	

Table 6.6d: Carbonised plant macrofossil total for each block (Ubiquity scores: wild plants continued)

Block	CC-3	GE	DB-P	DB-M	DB-S	AD-IA	GUN-IA	CN-W	CN-C	CN-R	LB-R	LB-C
Period	BA	EIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	MIA	LIA-I	LIA-I
Number of samples	12	18	1	1	1	10	12	3	1	4	1	20
Polygonum aviculare L. (N)	25	6					8.3					20
Polygonum cf. *aviculare* L. (N)					100							
Polygonum cf. *oxyspermum* (M. & B. ex Lb.) (N)					100							
Polygonum spp. (N)	67			100	100	30				25	100	20
Potentilla erecta (L.) Raeusch (S)											100	
Potentilla sp. (S)												5
Pteridium aquilinium (L.) Kuhn (LF)												
Ranunculus acris L. (A)												
Ranunculus bulbosus L. (A)												
Ranunculus cf. *bulbosus* L. (A)					100							
Ranunculus cf. *repens* L. (A)	33				100							
Ranunculus repens L. (A)												5
Ranunculus spp. (A)	42											10
Raphanus raphanistrum L. (F)	17											
Rumex acetosa L. (N)	8										100	
Rumex acetosella L. (N)	42	6				10	16.7					5
Rumex cf. *crispus* L. (N)	83											
Rumex crispus L. (N)	83					20	41.7			25	100	40
Rumex spp. (N)	33					20	16.7				100	30
Sinapis arvensis L. (S)												5
Sorbus aucuparia L. (S)		6										
Sorbus sp. (S)	8											5
Spergula arvensis L. (S)	8						8.3					
Stachys cf. *palustris* L. (F)	42											
Stachys spp. (F)	8											
Stellaria media (L.) Villars (S)	50		100	100	100	20	41.7				100	15
Trifolium repens L. (S)												
Trifolium sp. (S)											100	
Urtica dioica L. (F)	8											
Urtica urens L. (F)	8											
Vaccinium myrtillus L. (S)	17					20	8.3					5
Vaccinium vitis-idaea L. (S)	17						8.3					
Vicia sativa L. (S)	8											
Vicia/Lathyrus spp. (S)						10						
Viola sp. (S)					100		8.3			25	100	5
Cereal/monocotyledon (<2 mm.) (CN)	92	6	100		100	20	33.3			25	100	35
Cereal/monocotyledon (<2 mm.) (CB)	100	56			100	80	91.7	33.3		100	100	65
Indeterminate (>2 mm.) (R)	75	83				40	91.7	33.3		25	100	65
Indeterminate (<2 mm.) (R)	92	39			100	80	100			25	100	35
Indeterminate (trigonous) (S/F)							8.3				100	
Indeterminate pericarp fragment (P)	8						16.7					5
Indeterminate seed/fruit (S/F)	100	17			100	60	75		100	50	100	65
Moss fragments (carbonised) (LF)												
Seaweed (LF)												5

Table 6.6e: Carbonised plant macrofossil total for each block (Ubiquity scores: wild plants continued)

Block	GAL-LIA	BO-E	BO-LIA	LB-LIA	BO-LIA/N	BO-N	GAL-N/M	AD-M
Period	LIA-I	LIA-I	LIA-II	LIA-II	LIA/N	N/EM	N/EM	N/EM
Number of samples	2	1	80	4	26	11	10	3
Polygonum aviculare L. (N)			11		19	27.3		
Polygonum cf. *aviculare* L. (N)								33.3
Polygonum cf. *oxyspermum* (M. & B. ex Lb.) (N)								
Polygonum spp. (N)	50		23	50	38	18.2	20	33.3
Potentilla erecta (L.) Raeusch (S)					4			
Potentilla sp. (S)								
Pteridium aquilinium (L.) Kuhn (LF)			6					
Ranunculus acris L. (A)							10	
Ranunculus bulbosus L. (A)			1		4	9.1	10	
Ranunculus cf. *bulbosus* L. (A)								
Ranunculus cf. *repens* L. (A)								
Ranunculus repens L. (A)			5		4	9.1		
Ranunculus spp. (A)			8		4	9.1		33.3
Raphanus raphanistrum L. (F)			1		4			
Rumex acetosa L. (N)			3	25	8			
Rumex acetosella L. (N)			20	25	12	9.1	10	
Rumex cf. *crispus* L. (N)								
Rumex crispus L. (N)		100	53	25	62	36.4	20	
Rumex spp. (N)		100	24		27	18.2	50	
Sinapis arvensis L. (S)								
Sorbus aucuparia L. (S)								
Sorbus sp. (S)								
Spergula arvensis L. (S)			16	50	12	27.3	10	
Stachys cf. *palustris* L. (F)			6					
Stachys spp. (F)								
Stellaria media (L.) Villars (S)			8	2.7	15		50	
Trifolium repens L. (S)			5					
Trifolium sp. (S)								
Urtica dioica L. (F)			11				10	
Urtica urens L. (F)								
Vaccinium myrtillus L. (S)						9.1		
Vaccinium vitis-idaea L. (S)						9.1		
Vicia sativa L. (S)						9.1		
Vicia/Lathyrus spp. (S)					4			
Viola sp. (S)			1		8			
Cereal/monocotyledon (<2 mm.) (CN)	50		44		50	9.1	30	33.3
Cereal/monocotyledon (<2 mm.) (CB)	50	100	68	50	62	54.5	40	100
Indeterminate (>2 mm.) (R)	50		21	50	31	45.5	40	100
Indeterminate (<2 mm.) (R)	50		14		23	18.2	60	100
Indeterminate (trigonous) (S/F)			36		19	18.2	60	
Indeterminate pericarp fragment (P)			6		4			
Indeterminate seed/fruit (S/F)	50		63	75	60	54.5	10	66.7
Moss fragments (carbonised) (LF)			1					
Seaweed (LF)			5		4	9.1		

Table 6.6f: Carbonised plant macrofossil total for each block (Ubiquity scores: wild plants continued)

Block	**GE**	**DB-P**	**DB-M**	**DB-S**	**DB-S**	**AD-IA**	**GUN-IA**	**CN-W**	**CN-C**	**CN-R**
Period	**EIA**	**EIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**
No. of samples	**26**	**1**	**1**	**3 (bulk)**	**6 (hand)**	**24**	**15**	**3**	**7**	**5**
No. of ids	**250**	**28**	**2**	**7**	**785**	**105**	**70**	**35**	**90**	**67**
Deciduous roundwood										
Alnus sp. roundwood	1					2	1			
Bark roundwood	1					1				
Betula sp. roundwood	33	2			15	10	11		17	
Calluna vulgaris (L.) roundwood	50	17	1	4	12	27	16			
Corylus sp. roundwood	6					8				3
Pomoideae undiff. roundwood	7					5	1			
Prunus sp. roundwood						2				
Rhamnus catharticus L. rwood						1				
Salix sp. roundwood							1		34	13
Deciduous roundwood total	**98**	**19**	**1**	**4**	**27**	**56**	**30**	**0**	**51**	**16**
Deciduous timber										
Alnus sp.	5									
Betula sp.	31				3	1				
Corylus sp.				1		3				
Fraxinus sp.	1									
Pomoideae undiff.										
Quercus sp.	4					1				45
Salix sp.								4	10	
Deciduous timber total	**41**	**0**	**0**	**1**	**3**	**5**	**0**	**4**	**10**	**45**
Coniferous roundwood										
Juniperis sp. roundwood							2			
Pinus sp. roundwood	1				3		2	30	18	
Coniferous roundwood total	**1**	**0**	**0**	**0**	**3**	**0**	**4**	**30**	**18**	**0**
Coniferous timber										
Abies sp.							7			
Coniferae indet.							3			
Larix sp.	1						15			
Picea sp.	4			1	204	9	3			
Pinus sp.	32	1	1	1	531	11	2			
Pinus sp. bark					3					
Pseudotsoga taxifolia L.										
Coniferous timber total	**37**	**1**	**1**	**2**	**738**	**20**	**30**	**0**	**0**	**0**
Indeterminate										
Indet. roundwood/rootwood	42	6				20	5	1	11	6
Indet.	28	2			14	4	1			
Bark fragment	3									
Seaweed										
Indeterminate total	**73**	**8**	**0**	**0**	**14**	**24**	**6**	**1**	**11**	**6**
Total id fragments	**250**	**28**	**2**	**7**	**785**	**105**	**70**	**35**	**90**	**67**

Table 6.7a: Charcoal fragment total for each block (Quantifiable fragments)

Block	**LB-R**	**LB-C**	**GAL-LIA**	**BO-E**	**LB-I**	**BO-LIA**	**LB-LIA**	**BO-LIA/N**	**BO-N**	**GAL-N/M**	**AD-M**
Period	**LIA-I**	**LIA-I**	**LIA-I**	**LIA-I**	**LIA-II**	**LIA-II**	**LIA-II**	**LIA/N**	**N/EM**	**N/EM**	**N/EM**
No. of samples	**1**	**22**	**2**	**1**	**3**	**9**	**3**	**10**	**7**	**5**	**1**
No. of ids	**20**	**371**	**12**	**2**	**14**	**35**	**32**	**75**	**63**	**23**	**20**
Deciduous roundwood											
Alnus sp. roundwood		2									
Bark roundwood		3									
Betula sp. roundwood	3	32	2			1	3	3	8	1	
Calluna vulgaris (L.) roundwood	8	165	2	1	6	14	9	18	15	5	7
Corylus sp. roundwood	1	23				0	1	0	3		
Pomoideae undiff. roundwood	1	3				0		1	0		
Prunus sp. roundwood											
Rhamnus catharticus L. rwood											
Salix sp. roundwood						1		4	3		
Deciduous roundwood total	**13**	**228**	**4**	**1**	**6**	**16**	**13**	**26**	**29**	**6**	**7**
Deciduous timber											
Alnus sp.		1				0	0	2	0	3	
Betula sp.		31				2	1	6	6	3	
Corylus sp.		1				0	0	0	1	2	
Fraxinus sp.											
Pomoideae undiff.		1									
Quercus sp.			1								
Salix sp.		1				0		0	2		
Deciduous timber total	**0**	**35**	**1**	**0**	**0**	**2**	**1**	**8**	**9**	**8**	**0**
Coniferous roundwood											
Juniperis sp. roundwood											
Pinus sp. roundwood						0		4	0		2
Coniferous roundwood total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**2**
Coniferous timber											
Abies sp.		5					1			1	
Coniferae indet.						5		5	2		
Larix sp.		1				3		2	3		
Picea sp.	1	13				1		10	1	2	1
Pinus sp.		18	4		1	6		7	2	6	5
Pinus sp. bark											
Pseudotsoga taxifolia L.		1									
Coniferous timber total	**1**	**38**	**4**	**0**	**1**	**15**	**1**	**24**	**8**	**9**	**6**
Indeterminate											
Indet. roundwood/rootwood	6	54	3		5	1	10	9	8		4
Indet.		10			2	0	7	2	5		1
Bark fragment		6		1		0		2	3		
Seaweed						1			1		
Indeterminate total	**6**	**70**	**3**	**1**	**7**	**2**	**17**	**13**	**17**	**0**	**5**
Total id fragments	**20**	**371**	**12**	**2**	**14**	**35**	**32**	**75**	**63**	**23**	**20**

Table 6.7b: Charcoal fragment total for each block (Quantifiable fragments continued)

Block	GE	DB-P	DB-M	DB-S	DB-S	AD-IA	GUN-IA	CN-W	CN-C	CN-R
Period	**EIA**	**EIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**
No. of samples	**26**	**1**	**1**	**3 (bulk)**	**6 (hand)**	**24**	**15**	**3**	**7**	**5**
No. of ids	**250**	**28**	**2**	**7**	**785**	**105**	**70**	**35**	**90**	**67**
Deciduous roundwood										
Alnus sp. roundwood	0.4	0.0	0.0	0.0	0.0	1.9	1.4	0.0	0.0	0.0
Bark roundwood	0.4	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Betula sp. roundwood	13.2	7.1	0.0	0.0	1.9	9.5	15.7	0.0	18.9	0.0
Calluna vulgaris (L.) roundwood	20.0	60.7	50.0	57.1	1.5	25.7	22.9	0.0	0.0	0.0
Corylus sp. roundwood	2.4	0.0	0.0	0.0	0.0	7.6	0.0	0.0	0.0	4.5
Pomoideae undiff. roundwood	2.8	0.0	0.0	0.0	0.0	4.8	1.4	0.0	0.0	0.0
Prunus sp. roundwood	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0
Rhamnus catharticus L. rwood	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Salix sp. roundwood	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	37.8	19.4
Deciduous roundwood total	39.2	67.9	50.0	57.1	3.4	53.3	42.9	0.0	56.7	23.9
Deciduous timber	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alnus sp.	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Betula sp.	12.4	0.0	0.0	0.0	0.4	1.0	0.0	0.0	0.0	0.0
Corylus sp.	0.0	0.0	0.0	14.3	0.0	2.9	0.0	0.0	0.0	0.0
Fraxinus sp.	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pomoideae undiff.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quercus sp.	1.6	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	67.2
Salix sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.4	11.1	0.0
Deciduous timber total	16.4	0.0	0.0	14.3	0.4	4.8	0.0	11.4	11.1	67.2
Coniferous roundwood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juniperis sp. roundwood	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0
Pinus sp. roundwood	0.4	0.0	0.0	0.0	0.4	0.0	2.9	85.7	20.0	0.0
Coniferous roundwood total	0.4	0.0	0.0	0.0	0.4	0.0	5.7	85.7	20.0	0.0
Coniferous timber	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Abies sp.	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0
Coniferae indet.	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0
Larix sp.	0.4	0.0	0.0	0.0	0.0	0.0	21.4	0.0	0.0	0.0
Picea sp.	1.6	0.0	0.0	14.3	26.0	8.6	4.3	0.0	0.0	0.0
Pinus sp.	12.8	3.6	50.0	14.3	67.6	10.5	2.9	0.0	0.0	0.0
Pinus sp. bark	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
Pseudotsoga taxifolia L.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coniferous timber total	14.8	3.6	50.0	28.6	94.0	19.0	42.9	0.0	0.0	0.0
Indeterminate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indet. roundwood/rootwood	16.8	21.4	0.0	0.0	0.0	19.0	7.1	2.9	12.2	9.0
Indet.	11.2	7.1	0.0	0.0	1.8	3.8	1.4	0.0	0.0	0.0
Bark fragment	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Seaweed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indeterminate total	29.2	28.6	0.0	0.0	1.8	22.9	8.6	2.9	12.2	9.0
Total id fragments	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 6.8a: Charcoal fragment total for each block (Proportion of total assemblage)

Block	LB-R	LB-C	GAL-LIA	BO-E	LB-I	BO-LIA	LB-LIA	BO-LIA/N	BO-N	GAL-N/M	AD-M
Period	**LIA-I**	**LIA-I**	**LIA-I**	**LIA-I**	**LIA-II**	**LIA-II**	**LIA-II**	**LIA/N**	**N/EM**	**N/EM**	**N/EM**
No. of samples	**1**	**22**	**2**	**1**	**3**	**9**	**3**	**10**	**7**	**5**	**1**
No. of ids	**20**	**371**	**12**	**2**	**14**	**35**	**32**	**75**	**63**	**23**	**20**
Deciduous roundwood											
Alnus sp. roundwood	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bark roundwood	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Betula sp. roundwood	15.0	8.6	16.7	0.0	0.0	2.9	9.4	4.0	12.7	4.3	0.0
Calluna vulgaris (L.) roundwood	40.0	44.5	16.7	50.0	42.9	40.0	28.1	24.0	23.8	21.7	35.0
Corylus sp. roundwood	5.0	6.2	0.0	0.0	0.0	0.0	3.1	0.0	4.8	0.0	0.0
Pomoideae undiff. roundwood	5.0	0.8	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0
Prunus sp. roundwood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhamnus catharticus L. rwood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix sp. roundwood	0.0	0.0	0.0	0.0	0.0	2.9	0.0	5.3	4.8	0.0	0.0
Deciduous roundwood total	65.0	61.5	33.3	50.0	42.9	45.7	40.6	34.7	46.0	26.1	35.0
Deciduous timber	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alnus sp.	0.0	0.3	0.0	0.0	0.0	0.0	0.0	2.7	0.0	13.0	0.0
Betula sp.	0.0	8.4	0.0	0.0	0.0	5.7	3.1	8.0	9.5	13.0	0.0
Corylus sp.	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.6	8.7	0.0
Fraxinus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pomoideae undiff.	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quercus sp.	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix sp.	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0
Deciduous timber total	0.0	9.4	8.3	0.0	0.0	5.7	3.1	10.7	14.3	34.8	0.0
Coniferous roundwood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juniperis sp. roundwood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pinus sp. roundwood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	0.0	10.0
Coniferous roundwood total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	0.0	10.0
Coniferous timber	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Abies sp.	0.0	1.3	0.0	0.0	0.0	0.0	3.1	0.0	0.0	4.3	0.0
Coniferae indet.	0.0	0.0	0.0	0.0	0.0	14.3	0.0	6.7	3.2	0.0	0.0
Larix sp.	0.0	0.3	0.0	0.0	0.0	8.6	0.0	2.7	4.8	0.0	0.0
Picea sp.	5.0	3.5	0.0	0.0	0.0	2.9	0.0	13.3	1.6	8.7	5.0
Pinus sp.	0.0	4.9	33.3	0.0	7.1	17.1	0.0	9.3	3.2	26.1	25.0
Pinus sp. bark	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pseudotsoga taxifolia L.	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coniferous timber total	5.0	10.2	33.3	0.0	7.1	42.9	3.1	32.0	12.7	39.1	30.0
Indeterminate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indet. roundwood/rootwood	30.0	14.6	25.0	0.0	35.7	2.9	31.3	12.0	12.7	0.0	20.0
Indet.	0.0	2.7	0.0	0.0	14.3	0.0	21.9	2.7	7.9	0.0	5.0
Bark fragment	0.0	1.6	0.0	50.0	0.0	0.0	0.0	2.7	4.8	0.0	0.0
Seaweed	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	1.6	0.0	0.0
Indeterminate total	30.0	18.9	25.0	50.0	50.0	5.7	53.1	17.3	27.0	0.0	25.0
Total id fragments	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 6.8b: Charcoal fragment total for each block (Proportion of total assemblage continued)

Block	**CC**	**GE**	**DB-P**	**DB-M**	**DB-S**	**DB-S**	**AD-IA**	**GUN-IA**	**CN-W**	**CN-C**	**CN-R**
Period	**BA**	**EIA**	**EIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**
No. of samples	**10**	**26**	**1**	**1**	**3 (bulk)**	**6 (hand)**	**24**	**15**	**3**	**7**	**5**
No. of ids	**w only**	**250**	**28**	**2**	**7**	**785**	**104**	**70**	**35**	**90**	**67**
Deciduous roundwood											
Alnus sp. roundwood		0.11					0.09	0.02			
Bark roundwood		0.12					0.03				
Betula sp. roundwood	0.11	3.92	0.19			4	0.36	0.27		0.44	
Calluna vulgaris (L.) roundwood		2.66	0.71	0.01	0.12	1.05	1.29	0.3			
Corylus sp. roundwood	0.54	0.38					0.54				0.07
Pomoideae undiff. roundwood		0.63					0.25	0.01			
Prunus sp. roundwood							0.03				
Rhamnus catharticus L. rwood							0.04				
Salix sp. roundwood	0.6							0.02		1.6	0.27
Deciduous roundwood total	**1.25**	**7.82**	**0.9**	**0.01**	**0.12**	**5.05**	**2.63**	**0.62**	**0**	**2.04**	**0.34**
Deciduous timber											
Alnus sp.		0.30									
Betula sp.	2.48	2.73				0.2	0.03				
Corylus sp.	2.91				0.02		0.11				
Fraxinus sp.		0.15									
Pomoideae undiff.											
Quercus sp.	0.19	0.15					0.01				2.61
Salix sp.	1.07								0.11	0.36	
Deciduous timber total	**6.65**	**3.33**	**0.00**	**0.00**	**0.02**	**0.20**	**0.15**	**0.00**	**0.11**	**0.36**	**2.61**
Coniferous roundwood											
Juniperis sp. roundwood								0.04			
Pinus sp. roundwood		0.09				0.05		0.03	1.26	0.65	
Coniferous roundwood total	**0.00**	**0.09**	**0.00**	**0.00**	**0.00**	**0.05**	**0.00**	**0.07**	**1.26**	**0.65**	**0.00**
Coniferous timber											
Abies sp.								0.72			
Coniferae indet.								0.03			
Larix sp.		0.81						0.52			
Picea sp.		0.13			0.03	103.96	0.78	0.16			
Pinus sp.		2.48	0.01	0.01	0.01	314.91	0.44	0.02			
Pinus sp. bark						0.6					
Pseudotsoga taxifolia L.											
Coniferous timber total	**0.00**	**3.42**	**0.01**	**0.01**	**0.04**	**419.47**	**1.22**	**1.45**	**0.00**	**0.00**	**0.00**
Indeterminate											
Indet. roundwood/rootwood		2.53	0.21				0.64	0.21	0.02	0.64	0.19
Indet.		2.66	0.08			1.07	0.1	0.01			
Bark fragment		0.45									
Indeterminate total	**0.00**	**5.64**	**0.29**	**0.00**	**0.00**	**1.07**	**0.74**	**0.22**	**0.02**	**0.64**	**0.19**
Total weight	7.90	20.30	1.20	0.02	0.18	425.84	4.74	2.36	1.39	3.69	3.14

Table 6.9a: Charcoal weight total for each block (Total weight)

Block	**LB-R**	**LB-C**	**GAL-LIA**	**BO-E**	**LB-I**	**BO-LIA**	**LB-LIA**	**BO-LIA/N**	**BO-N**	**GAL-N/M**	**AD-M**
Period	**LIA-I**	**LIA-I**	**LIA-I**	**LIA-I**	**LIA-II**	**LIA-II**	**LIA-II**	**LIA/N**	**N/EM**	**N/EM**	**N/EM**
No. of samples	**1**	**22**	**2**	**1**	**3**	**9**	**3**	**10**	**7**	**5**	**1**
No. of ids	**20**	**371**	**12**	**2**	**14**	**35**	**32**	**75**	**63**	**23**	**20**
Deciduous roundwood											
Alnus sp. roundwood		0.11									
Bark roundwood		0.05									
Betula sp. roundwood	0.16	1.16	0.04			0.04	0.12	0.06	0.45	0.04	
Calluna vulgaris (L.) roundwood	0.4	6.45	0.04	0.06	0.17	0.35	0.41	0.73	0.67	0.18	0.3
Corylus sp. roundwood	0.04	1.01					0.06		0.1		
Pomoideae undiff. roundwood	0.12	0.1						0.02			
Prunus sp. roundwood											
Rhamnus catharticus L. rwood											
Salix sp. roundwood						0.02		0.91	0.1		
Deciduous roundwood total	**0.72**	**8.88**	**0.08**	**0.06**	**0.17**	**0.41**	**0.59**	**1.72**	**1.32**	**0.22**	**0.3**
Deciduous timber											
Alnus sp.		0.11						0.17		0.08	
Betula sp.		0.82				0.05	0.04	0.2	0.32	0.1	
Corylus sp.		0.04							0.08	0.05	
Fraxinus sp.											
Pomoideae undiff.		0.21									
Quercus sp.			0.01								
Salix sp.		0.01							0.21		
Deciduous timber total	**0.00**	**1.19**	**0.01**	**0.00**	**0.00**	**0.05**	**0.04**	**0.37**	**0.61**	**0.23**	**0.00**
Coniferous roundwood											
Juniperis sp. roundwood											
Pinus sp. roundwood								0.14			0.1
Coniferous roundwood total	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.14**	**0.00**	**0.00**	**0.10**
Coniferous timber											
Abies sp.		0.13					0.03			0.06	
Coniferae indet.						0.08		0.09	0.03		
Larix sp.		0.01				0.06		0.05	0.13		
Picea sp.	0.01	0.32				0.04		0.28	0.02	0.02	0.03
Pinus sp.		1.34	0.08		0.03	0.27		0.43	0.06	0.43	0.16
Pinus sp. bark											
Pseudotsoga taxifolia L.		0.16									
Coniferous timber total	**0.01**	**1.96**	**0.08**	**0.00**	**0.03**	**0.45**	**0.03**	**0.85**	**0.24**	**0.51**	**0.19**
Indeterminate											
Indet. roundwood/rootwood	0.18	2.05	0.05		0.18	0.02	0.34	0.25	0.23		0.21
Indet.		0.23			0.06		0.16	0.04	0.09		0.03
Bark fragment		0.11		0.02				0.02	0.11		
Indeterminate total	**0.18**	**2.39**	**0.05**	**0.02**	**0.24**	**0.02**	**0.50**	**0.31**	**0.43**	**0.00**	**0.24**
Total weight	0.91	14.42	0.22	0.08	0.44	0.93	1.16	3.39	2.60	0.96	0.83

Table 6.9b: Charcoal weight total for each block (Total weight continued)

Block	CC	GE	DB-P	DB-M	DB-S	DB-S	AD-IA	GUN-IA	CN-W	CN-C	CN-R
Period	**BA**	**EIA**	**EIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**
No. of samples	**10**	**26**	**1**	**1**	**3 (bulk)**	**6 (hand)**	**24**	**15**	**3**	**7**	**5**
No. of ids	**w only**	**250**	**28**	**2**	**7**	**785**	**104**	**70**	**35**	**90**	**67**
Deciduous roundwood											
Alnus sp. roundwood	0.0	0.5	0.0	0.0	0.0	0.0	1.9	0.8	0.0	0.0	0.0
Bark roundwood	0.0	0.6	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Betula sp. roundwood	1.4	19.3	15.8	0.0	0.0	0.9	7.6	11.4	0.0	11.9	0.0
Calluna vulgaris (L.) roundwood	0.0	13.1	59.2	50.0	66.7	0.2	27.2	12.7	0.0	0.0	0.0
Corylus sp. roundwood	6.8	1.9	0.0	0.0	0.0	0.0	11.4	0.0	0.0	0.0	2.2
Pomoideae undiff. roundwood	0.0	3.1	0.0	0.0	0.0	0.0	5.3	0.4	0.0	0.0	0.0
Prunus sp. roundwood	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Rhamnus catharticus L. rwood	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0
Salix sp. roundwood	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	43.4	8.6
Deciduous roundwood total	15.8	38.5	75.0	50.0	66.7	1.2	55.5	26.3	0.0	55.3	10.8
Deciduous timber	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alnus sp.	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Betula sp.	31.4	13.4	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Corylus sp.	36.8	0.0	0.0	0.0	11.1	0.0	2.3	0.0	0.0	0.0	0.0
Fraxinus sp.	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pomoideae undiff.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quercus sp.	2.4	0.7	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	83.1
Salix sp.	13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	9.8	0.0
Deciduous timber total	84.2	16.4	0.0	0.0	11.1	0.0	3.2	0.0	7.9	9.8	83.1
Coniferous roundwood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juniperis sp. roundwood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0
Pinus sp. roundwood	0.0	0.4	0.0	0.0	0.0	0.0	0.0	1.3	90.6	17.6	0.0
Coniferous roundwood total	0.0	0.4	0.0	0.0	0.0	0.0	0.0	3.0	90.6	17.6	0.0
Coniferous timber	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Abies sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5	0.0	0.0	0.0
Coniferae indet.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0
Larix sp.	0.0	4.0	0.0	0.0	0.0	0.0	0.0	22.0	0.0	0.0	0.0
Picea sp.	0.0	0.6	0.0	0.0	16.7	24.4	16.5	6.8	0.0	0.0	0.0
Pinus sp.	0.0	12.2	0.8	50.0	5.6	74.0	9.3	0.8	0.0	0.0	0.0
Pinus sp. bark	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Pseudotsoga taxifolia L.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coniferous timber total	0.0	16.8	0.8	50.0	22.2	98.5	25.7	61.4	0.0	0.0	0.0
Indeterminate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indet. roundwood/rootwood	0.0	12.5	17.5	0.0	0.0	0.0	13.5	8.9	1.4	17.3	6.1
Indet.	0.0	13.1	6.7	0.0	0.0	0.3	2.1	0.4	0.0	0.0	0.0
Bark fragment	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indeterminate total	0.0	27.8	24.2	0.0	0.0	0.3	15.6	9.3	1.4	17.3	6.1
Total weight	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 6.10a: Charcoal weight total for each block (Percentage of total weight)

Block	LB-R	LB-C	GAL-LIA	BO-E	LB-I	BO-LIA	LB-LIA	BO-LIA/N	BO-N	GAL-N/M	AD-M
Period	**LIA-I**	**LIA-I**	**LIA-I**	**LIA-I**	**LIA-II**	**LIA-II**	**LIA-II**	**LIA/N**	**N/EM**	**N/EM**	**N/EM**
No. of samples	**1**	**22**	**2**	**1**	**3**	**9**	**3**	**10**	**7**	**5**	**1**
No. of ids	**20**	**371**	**12**	**2**	**14**	**35**	**32**	**75**	**63**	**23**	**20**
Deciduous roundwood											
Alnus sp. roundwood	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bark roundwood	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Betula sp. roundwood	17.6	8.0	18.2	0.0	0.0	4.3	10.3	1.8	17.3	4.2	0.0
Calluna vulgaris (L.) roundwood	44.0	44.7	18.2	75.0	38.6	37.6	35.3	21.5	25.8	18.8	36.1
Corylus sp. roundwood	4.4	7.0	0.0	0.0	0.0	0.0	5.2	0.0	3.8	0.0	0.0
Pomoideae undiff. roundwood	13.2	0.7	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
Prunus sp. roundwood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rhamnus catharticus L. rwood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix sp. roundwood	0.0	0.0	0.0	0.0	0.0	2.2	0.0	26.8	3.8	0.0	0.0
Deciduous roundwood total	79.1	61.6	36.4	75.0	38.6	44.1	50.9	50.7	50.8	22.9	36.1
Deciduous timber	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alnus sp.	0.0	0.8	0.0	0.0	0.0	0.0	0.0	5.0	0.0	8.3	0.0
Betula sp.	0.0	5.7	0.0	0.0	0.0	5.4	3.4	5.9	12.3	10.4	0.0
Corylus sp.	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	3.1	5.2	0.0
Fraxinus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pomoideae undiff.	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quercus sp.	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salix sp.	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	8.1	0.0	0.0
Deciduous timber total	0.0	8.3	4.5	0.0	0.0	5.4	3.4	10.9	23.5	24.0	0.0
Coniferous roundwood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Juniperis sp. roundwood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pinus sp. roundwood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	12.0
Coniferous roundwood total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	12.0
Coniferous timber	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Abies sp.	0.0	0.9	0.0	0.0	0.0	0.0	2.6	0.0	0.0	6.3	0.0
Coniferae indet.	0.0	0.0	0.0	0.0	0.0	8.6	0.0	2.7	1.2	0.0	0.0
Larix sp.	0.0	0.1	0.0	0.0	0.0	6.5	0.0	1.5	5.0	0.0	0.0
Picea sp.	1.1	2.2	0.0	0.0	0.0	4.3	0.0	8.3	0.8	2.1	3.6
Pinus sp.	0.0	9.3	36.4	0.0	6.8	29.0	0.0	12.7	2.3	44.8	19.3
Pinus sp. bark	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pseudotsoga taxifolia L.	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coniferous timber total	1.1	13.6	36.4	0.0	6.8	48.4	2.6	25.1	9.2	53.1	22.9
Indeterminate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indet. roundwood/rootwood	19.8	14.2	22.7	0.0	40.9	2.2	29.3	7.4	8.8	0.0	25.3
Indet.	0.0	1.6	0.0	0.0	13.6	0.0	13.8	1.2	3.5	0.0	3.6
Bark fragment	0.0	0.8	0.0	25.0	0.0	0.0	0.0	0.6	4.2	0.0	0.0
Indeterminate total	19.8	16.6	22.7	25.0	54.5	2.2	43.1	9.1	16.5	0.0	28.9
Total weight	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 6.10b: Charcoal weight total for each block (Percentage of total weight continued)

Block	**CC**	**GE**	**DB-P**	**DB-M**	**DB-S**	**DB-S**	**AD-IA**	**GUN-IA**	**CN-W**	**CN-C**	**CN-R**
Period	**BA**	**EIA**	**EIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**	**MIA**
No. of samples	**10**	**26**	**1**	**1**	**3 (bulk)**	**6 (hand)**	**24**	**15**	**3**	**7**	**5**
No. of ids	**w only**	**250**	**28**	**2**	**7**	**785**	**105**	**70**	**35**	**90**	**67**
Deciduous roundwood											
Alnus sp. roundwood		3.8					4	7			
Bark roundwood		3.8					4				
Betula sp. roundwood	20	50	100			33	21	33		29	
Calluna vulgaris (L.) roundwood		54	100	100	33	33	50	53			
Corylus sp. roundwood	40	15					21				20
Pomoideae undiff. roundwood		19					8	7			
Prunus sp. roundwood							4				
Rhamnus catharticus L. rwood							4	7			
Salix sp. roundwood	40									71	20
Deciduous timber											
Alnus sp.		8									
Betula sp.	70	42					4				
Corylus sp.	60				33		8				
Fraxinus sp.		4									
Pomoideae undiff.											
Quercus sp.	10	12					4				20
Salix sp.	60								33	14	
Coniferous roundwood											
Juniperis sp. roundwood								13			
Pinus sp. roundwood		4				33		13	33	14	
Coniferous timber											
Abies sp.								7			
Coniferae indet.								20			
Larix sp.		4						47			
Picea sp.		8			33	83	8	13			
Pinus sp.		62	100	100	33	100	25	13			
Pinus sp. bark						17					
Pseudotsoga taxifolia L.											
Coniferous timber total											
Indeterminate											
Indet. roundwood/rootwood		62	100				49	20	33	29	40
Indet.		58	100				13	7			
Bark fragment		4									

Table 6.11a: Charcoal fragment ubiquity scores for each block

Block	LB-R	LB-C	GAL-LIA	BO-E	LB-I	BO-LIA	LB-LIA	BO-LIA/N	BO-N	GAL-N/M	AD-M
Period	**LIA-I**	**LIA-I**	**LIA-I**	**LIA-I**	**LIA-II**	**LIA-II**	**LIA-II**	**LIA/N**	**N/EM**	**N/EM**	**N/EM**
No. of samples	**1**	**22**	**2**	**1**	**3**	**9**	**3**	**10**	**7**	**5**	**1**
No. of ids	**20**	**371**	**12**	**2**	**14**	**35**	**32**	**75**	**63**	**23**	**20**
Deciduous roundwood											
Alnus sp. roundwood		9									
Bark roundwood		9									
Betula sp. roundwood	100	55	50			11	67	20	71	20	
Calluna vulgaris (L.) roundwood	100	91	50	100	67	67	100	30	71	40	100
Corylus sp. roundwood	100	45					33		29		
Pomoideae undiff. roundwood	100	14									
Prunus sp. roundwood											
Rhamnus catharticus L. rwood											
Salix sp. roundwood						11		40	14		
Deciduous timber											
Alnus sp.		5						10		20	
Betula sp.		59				22	33	30	29	40	
Corylus sp.		5							14	20	
Fraxinus sp.											
Pomoideae undiff.		5									
Quercus sp.			50								
Salix sp.		5							14		
Coniferous roundwood											
Juniperis sp. roundwood											
Pinus sp. roundwood								20			100
Coniferous timber											
Abies sp.		23					33			20	
Coniferae indet.						33		40	29		
Larix sp.		5				11		10	29		
Picea sp.	100	36				11		20	14	20	100
Pinus sp.		41	100		33	22		30	29	40	100
Pinus sp. bark											
Pseudotsoga taxifolia L.		5									
Coniferous timber total											
Indeterminate											
Indet. roundwood/rootwood	100	77	50		67	11	67	40	43		
Indet.		36			33		100	20	29		
Bark fragment		27		100				10			

Table 6.11b: Charcoal fragment ubiquity scores for each block (continued)

site block	cereal grain	barley rachis	oat floret base	large culm node	large culm base
GE	89	17		28	67
DB-P	100	100		100	100
DB-M		100			
DB-S	100	100		100	100
GUN-IA	41.7				58.3
CN-W	100	33.3			66.7
CN-C	100				100
CN-R	75	25		25	75
LB-R	100	100		100	100
LB-C	100	50		60	90
GAL-LIA	100				50
BO-E	100				
BO-LIA	93	15	3	14	63
LB-LIA	100				75
BO-LIA/N	96	12	4	38	69
BO-N	100		9.1		63.6
GAL-N/M	90	30	10	30	10

Table 7.1a: Evidence for cultivation during domestic block occupation (carbonised plant macrofossil Ubiquity scores)

	Landscape evidence	Artefactual evidence	
site block	cereal pollen	quern stones	other
GE	no coverage		
DB-P	Loch Bharabhat, Loch na Beirgh	present	
DB-M	Loch Bharabhat, Loch na Beirgh	present	
DB-S	Loch Bharabhat, Loch na Beirgh	present	
GUN-IA	no cereal pollen in Loch Ruadh Guinnerso		
CN-W	Loch na Beirgh, Loch Bharabhat	present	metal plough share
CN-C	Loch na Beirgh, Loch Bharabhat	present	
CN-R	Loch na Beirgh, Loch Bharabhat	present	
LB-R	Loch na Beirgh, Loch Bharabhat	present	
LB-C	Loch na Beirgh, Loch Bharabhat	present	various antler picks and handles
GAL-LIA	no coverage		
BO-E	no coverage		
BO-LIA	no coverage	present	various antler picks and handles
LB-LIA	Loch na Beirgh, Loch Bharabhat	present	some antler picks
BO-LIA/N	no coverage	present	possible antler pick
BO-N	no coverage	present	possible antler pick
GAL-N/M	no coverage		

Table 7.1b: Evidence for cultivation during domestic block occupation (supporting evidence)

Processing stage	Description	Archaeological remains
Seed processing		
Rippling	Heads of plants (bolls) drawn through strong comb then bolls separated from stem by coarse sieving.	Comb and sieve.
Drying	Bolls dried prior to storage or pressing.	Accidents in drying (seeds carbonised).
Pressing	Bolls and seeds ground for oil production.	Various ground stone tools.
Fibre processing		
Retting	Substances that bind fibres in stem are decomposed in fields or accelerated process in water.	Water management structures.
Pounding	Bark and fibre broken up by various pounding methods.	Pounding equipment (varies in form).
Scutching	Fibres separated from stem and bark through use of specialised tool kit.	Specialised tool kit (varies in form). Waste products incorporated into domestic hearths as fuel or fodder (seeds, stem parts and rhizomes carbonised).
Hackling/heckling	Final preparation of fibres for spinning using specialised tool kit.	Specialised tool kit (varies in form).
Spinning and weaving	Spinning and weaving using specialised tool kit.	Specialised tool kit (varies in form).

Table 7.2: Processing stages for flax (descriptions following Bond & Hunter, 1987)

Block	Number of samples	Number of seeds	Mean length (mm)	Length range (mm)	Mean breadth (mm)	Breadth range (mm)
AD-IA	1	1	3	n/a	1.5	n/a
LB-R	1	2	3.5	3.4-3.6	1.75	1.7-1.8
LB-C	2	5	3.26	3.1-3.6	1.72	1.4-1.8
LB-LIA	2	32	2.94	2.1-3.4	1.48	1.1-1.7
BO-LIA (<20 seeds)	28	76	2.9	2.2-4.6	1.52	1.2-2.1
BO-LIA (S.155)	1	50 of 200	3	2.6-3.4	1.51	1.3-1.9
BO-LIA (S.287)	1	34	2.95	2.5-3.5	1.56	1.3-2
BO-LIA (S.326)	1	50 of 912	2.91	2.4-3.3	1.51	1.3-1.9
BO-LIA/N	4	7	2.79	2.6-3	1.47	1.3-1.7
BO-N	4	12	2.95	2.6-3.2	1.59	1.3-2
GAL-N/M	1	1	3.3	n/a	1.6	n/a
Total	**46**	**270**	**2.94**	**2.1-4.6**	**1.52**	**1.1-2.1**

Table 7.3: Average size of flax seeds from all blocks

Block	Flax	Corn spurrey	Chickweed	Flax and Corn spurrey	Flax, Corn spurrey and Chickweed
CC-3		1 of 12	6 of 12		
GE					
AD-IA	1 of 12		2 of 12		
GUN-IA		1 of 12	5 of 12		
LB-C	2 of 20		3 of 20		
BO-LIA	31 of 80	13 of 80	6 of 80	10 of 13	3 of 6
BO-LIA/N	4 of 26	3 of 26	4 of 26	0 of 3	0 of 3
BO-N	4 of 11	3 of 11		2 of 3	

Table 7.4: Ubiquity counts for flax, Corn spurrey and Chickweed from each site block with at least 10 samples

Crop	Product	Secondary product / use	Archaeological remains
Barley and oat	Straw	Fodder	Carbonised in hearths, waterlogged remains (e.g. Dun Bharabhat).
		Furnishings	Thatch in conflagrations (e.g **DB-S** C.169).
		Fuel	Carbonised in hearths.
		Artefact production	Waterlogged remains (e.g. Dun Bharabhat).
	Other chaff	Fodder	Carbonised in hearths, waterlogged remains (e.g. Dun Bharabhat).
		Fuel	Carbonised in hearths.
	Grain	Bread	Carbonised bread from cooking accidents, pot residue
		Broth	Barley bran in coprolites, pot residue
		Ale	Malted barley carbonised, pot residue.
Flax	Seed	Oil	See Table 7.2.
	Fibre	Cloth	See Table 7.2.

Table 7.5: Products and by-products of crops

	Ring count	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20+**	
Block	**No. of samples**																					**Dec rwood frags**
GE	26		1	1	3	7	5	4						1								**22**
DB-P	1			2																		**2**
DB-M	1																					**0**
DB-S	3 (bulk)																					**0**
DB-S	6 (hand)			3	3	2	1	2	1	2		1										**15**
AD-IA	24			2	1	2	1	1								1						**8**
GUN-IA	15			1	2	3		3														**9**
LB-R	1				1	1	2					1										**5**
LB-C	22	1	1	1	3	9	10	2	2	2		2			2							**35**
GAL-LIA	2																					**0**
BO-E	1																					**0**
LB-I	3																					**0**
BO-LIA	9				1			1														**2**
LB-LIA	3																					**0**
BO-LIA/N	10	1		1		1																**3**
BO-N	7				3	1	1							1	1							**7**
GAL-N/M	5					1																**1**
AD-M	1																					**0**
	Total	**2**	**2**	**11**	**17**	**27**	**20**	**13**	**3**	**4**	**0**	**4**	**0**	**2**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**109**

Table 7.6: Ring counts for deciduous roundwood (pith to bark - excluding Ling heather) from all blocks

	Ring count	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	
Block	**No. of samples**																					**Conif rwood frags**
GE	26			1																		**1**
DB-P	1																					**0**
DB-M	1																					**0**
DB-S	3 (bulk)																					**0**
DB-S	6 (hand)									1		1			1							**3**
AD-IA	24																					**0**
GUN-IA	15													1	1				1			**3**
LB-R	1																					**0**
LB-C	22																					**0**
GAL-LIA	2																					**0**
BO-E	1																					**0**
LB-I	3																					**0**
BO-LIA	9																					**0**
LB-LIA	3																					**0**
BO-LIA/N	10						1															**1**
BO-N	7																					**0**
GAL-N/M	5																					**0**
AD-M	1																					**0**
	Total	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**1**	**0**	**1**	**2**	**0**	**0**	**0**	**1**	**0**	**0**	

Table 7.7: Ring counts for coniferous roundwood (pith to bark) from all blocks

	Ring count	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	
Block	**No. of samples**																					**Dec timber frags**
GE	26	8	10	11	11	2	1	1		1		1										**46**
DB-P	1																					**0**
DB-M	1																					**0**
DB-S	3 (bulk)				1																	**1**
DB-S	6 (hand)			1													2					**3**
AD-IA	24	3						1	1				1									**6**
GUN-IA	15																					**0**
LB-R	1																					**0**
LB-C	22		8	7	1	3	3	1	1	1					1	1						**27**
GAL-LIA	2		1																			**1**
BO-E	1																					**0**
LB-I	3																					**0**
BO-LIA	9		1	1																		**2**
LB-LIA	3			1																		**1**
BO-LIA/N	10	1	3			1	2									1						**8**
BO-N	7		1	2	2	1																**6**
GAL-N/M	5																					**0**
AD-M	1																					**0**
	Total	**12**	**24**	**23**	**15**	**7**	**6**	**3**	**2**	**2**	**0**	**1**	**1**	**0**	**1**	**2**	**2**	**0**	**0**	**0**	**0**	**101**

Table 7.8: Ring counts for deciduous timber from all blocks

	Ring count	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	
Block	**No. of samples**																					**Conif timber frags**
GE	26	2	5	7	2	3	2	1	1		2		1	1		1			1		7	**36**
DB-P	1				1																	**1**
DB-M	1				1																	**1**
DB-S	3 (bulk)			2	2	1	1		1		1									1		**9**
DB-S	6 (hand)		80	100	77	84	53	40	35	24	16	25	19	15	17	24	17	7	5	5	92	**735**
AD-IA	24	3	10	2	1	2								1								**19**
GUN-IA	15		9	8	4	2	2	3			1										2	**31**
LB-R	1			1																		**1**
LB-C	22	1	2	11	5	6	2	2	1	2	1	2		1					1		1	**38**
GAL-LIA	2	2		1																	1	**4**
BO-E	1																					**0**
LB-I	3						1															**1**
BO-LIA	9	5	2	3	1	2	1					1										**15**
LB-LIA	3			1																		**1**
BO-LIA/N	10	5	4	2	7		1	2			1					1					1	**24**
BO-N	7		2	1		2	1			1					1							**8**
GAL-N/M	5		1	1				1		1	1					1				1	2	9
AD-M	1	1	1	1									2							1		**6**
	Total	**19**	**116**	**141**	**101**	**102**	**64**	**49**	**38**	**28**	**23**	**28**	**22**	**18**	**18**	**27**	**17**	**7**	**7**	**8**	**106**	
	Total (ex. DB-S hand)	**19**	**36**	**41**	**24**	**18**	**11**	**9**	**3**	**4**	**7**	**3**	**3**	**3**	**1**	**3**	**0**	**0**	**2**	**3**	**14**	

Table 7.9: Ring counts for coniferous timber for all blocks

Site	Blocks of analysis	Sampling strategy	Remains
Shetland			
Mavis Grind	MG-EIA	Judgement (bulk)	Macrofossils and charcoal (Dickson, 1983b)
Clickhimin	CL-EIA, MIA	Judgement (hand-retrieved)	Charcoal (Green, 1968)
Jarlshof	J-M/LIA, J-N	Judgement (hand-retrieved)	Charcoal (Orr, 1934a; Orr & Green, 1956)
East shore broch	ESB-LIA	Total (bulk)	Macrofossils (Boardman, 1995b)
Kebister	K-MIA, LIAI, LIAII, N	Total (bulk)	Macrofossils & charcoal (Dickson, 1999)
Scalloway	SC-EIA, MIA, LIAI, LIAII	Total (bulk)	Macrofossils (Holden & Boardman, 1998; Holden, 1998b), charcoal (Crone, 1998)
Old Scatness	OS-MIA, LIA, N	Total (bulk)	Macrofossils (Bond *et al.*, forth. a & b)
Orkney			
Bu	BU-EIA	Judgement (bulk)	Macrofossils & charcoal (Dickson, 1987a)
Knowes of Quoyscottie	KQ-EIA	Judgement (hand-retrieved)	Charcoal (Jones, 1977)
Tofts Ness	TN-EIA	Total (bulk)	Interim statement on macros (Dockrill *et al.*, 1994)
Howe	HH-EIA, MIA, LIA	Total (bulk)	Macrofossils & charcoal (Dickson, 1994)
St. Boniface	SB-EIA, MIA, LIA, N	Total (bulk)	Macrofossils (Boardman, 1999), charcoal (Crone, 1999)
Broch of Burrian	BB-MIA	Judgement (hand-retrieved)	Macrofossils (Chadwick, 1974)
Gurness	GU-M/LIA	Judgement (hand-retrieved)	Macrofossils & charcoal (Dickson, 1987b)
Warebeth broch	WB-LIA	Judgement (hand-retrieved)	Human coprolites (Bell & Dickson, 1989)
Pool	PO-LIA, N	Total (bulk)	Interim statement on macros (Bond, 1998)
Brough of Birsay A	BBA-N	Judgement (hand-retrieved)	Charcoal (Donaldson, 1982)
Brough of Birsay B	BBB-LIAII, N	Judgement (bulk)	Macrofossils & charcoal (Donaldson, 1986b)
Brough of Birsay C	BBC-LIAII/N	Judgement (bulk & hand-retrieved)	Macrofossils & charcoal (Donaldson & Nye, 1989)
Brough of Birsay D	BBD-N	Total (bulk)	Macrofossils & charcoal (Rackham, 1996; Nye, 1996)
Brough of Deerness	BD-N	Judgement (hand-retrieved)	Charcoal (Donaldson, 1986a)
Earl's Bu	EB-N	Total (bulk)	Interim statement on macros & charcoal (Batey & Morris, 1992)
Saevar Howe	SV-N	Judgement (bulk)	Macrofossils & charcoal (Dickson, 1983c)
Tuquoy	TU-N	Total (bulk)	Interim statement on macros & charcoal (Owen, 1993; Dickson & Dickson, 2000)

Table 8.1a: Archaeobotanical assemblages across Atlantic Scotland (Shetland and Orkney)

Site	Blocks of analysis	Sampling strategy	Remains
Sutherland & Caithness			
Cyderhall	CY-EIA	Judgement (bulk)	Macrofossils (Boardman, 1992), charcoal (Crone, 1992)
Crosskirk	CK-EIA, MIA, LIA	Judgement (bulk)	Macrofossils & charcoal (Dickson & Dickson, 1984)
Freswick Castle	FC-N	Judgement (hand-retrieved)	Macrofossils & charcoal (Donaldson, 1984)
Freswick	F-LIAII, N	Total and random* (bulk)	Macrofossils (Huntley & Turner, 1995), charcoal (Nye, 1995)
Upper Suisgill	US-EIA, MIA	Judgement (bulk)	Macrofossils (van der Veen, 1985b)
Lairg	LA-EIA, M/LIA	Total (bulk)	Macrofossils (Holden, 1998a), charcoal (Crone *et al.*, 1998)
Argyll, Inner Hebrides and Skye			
Balevullin	BA-EIA	Judgement (hand-retrieved)	Charcoal (Brett, 1965)
Cul a'Bhaile	CB-EIA	Judgement (hand-retrieved)	Charcoal (Dickson, 1984)
Dun Mor Vaul	DMV-EIA, MIA	Judgement (hand-retrieved)	Macrofossils (Renfrew, 1974), charcoal (Pilcher, 1974)
Acharn	AC-MIA	Judgement (hand-retrieved)	Charcoal (Dickson, 1988)
Balloch Hill	BH-MIA	Judgement (bulk)	Macrofossils & charcoal (Dickson, 1982)
Dunadd	D-MIA, LIA	Judgement (bulk)	Macrofossils (Milles, 2000), charcoal (Boyd, 2000)
Rudh'an Dunain Cave	RAD-M/LIA	Judgement (hand-retrieved)	Charcoal (Orr, 1934b)
Dun Beag	DB-LIA	Judgement (hand-retrieved)	Macrofossils (Orr, 1921)
Kildonan bay	KB-LIA	Judgement (hand-retrieved)	Charcoal (Orr, 1939)
Ardnave	AR-LIAI	Judgement (bulk)	Charcoal (Dickson, 1983a)
Dun Cul Bhuirg	DCB-LIAI	Judgement (hand-retrieved)	Macrofossils & charcoal (Dickson, 1980)
Iona	IO-LIAII	Judgement (hand and bulk)	Uncarbonised wood (Barber, 1981), macrofossils (Fairweather, 1981)
Machrins	MA-LIAI, LIAII	Judgement (bulk)	Macrofossils (Dickson, 1981)

* 20% random selection of samples for non-cereal plant macrofossil identification

Table 8.1b: Archaeobotanical assemblages across Atlantic Scotland (Sutherland & Caithness; Inner Hebrides and Argyll)

Remains	**Carbonised macros**	**Charcoal**	**Uncarbonised macros & wood**	**Coprolites**				**Total**
Number of blocks	50 (75%)	51 (76%)	1 (1%)	1 (1%)				n/a
Area	**Shetland**	**Orkney**	**Caithness & Sutherland**	**Argyll, Inner Hebrides & Skye**				
Number of blocks	17 (25%)	24 (37%)	11 (16%)	15 (22%)				67
Period	**EIA**	**MIA**	**LIA**	**LIAI**	**LIAII**	**N**	**Multi-period**	
Number of blocks	15 (23%)	13 (19%)	11 (16%)	4 (6%)	6 (9%)	14 (21%)	4 (6%)	67
Sampling strategy	**Judgement (hand)**	**Judgement (bulk)**	**Total (bulk)**					
Number of blocks	19 (28%)	19 (28%)	29 (44%)					67

Table 8.2: Statistical breakdown of Atlantic Scottish archaeobotanical dataset

Block	CL-EIA	MG-EIA	SC-EIA	CL-MIA	K-MIA	OS-MIA	SC-MIA	J-M/LIA	ESB-LIA	OS-LIA	K-LIAI	SC-LIAI	K-LIAII	SC-LIAII	J-N	K-N	OS-N
Number of samples (bulk macros)	**n/a**	**15**	**1**	**n/a**	**14**	**n/a**	**23**	**n/a**	**32**	**n/a**	**19**	**20**	**1**	**44**	**n/a**	**1**	**n/a**
Number of samples (bulk charcoal)	**n/a**	**10**	**0**	**n/a**	**14**	**n/a**	**7**	**n/a**	**32**	**n/a**	**19**	**10**	**1**	**8**	**n/a**	**1**	**n/a**
Cultivated																	
Hordeum vulgare L.		53	p		64	a	100	p	a	a	68	90	p	89		p	a
Hordeum sp. naked					14	p	9				5	10		2			
Hordeum sp. hulled		53	p		29	a	100	p	a	a	42	95	p	93			a
Avena sp.					43		39		p	a	32	50	p	70			a
Avena strigosa L.										p	5						p
Linum usitissimum L.											5			5			p
Triticum dicoccum Schubl.									p								
Charcoal																	
Roundwood																	
Calluna vulgaris (L.) roundwood	p	90			93		a		a		68	100	p	a		p	
Juniperis sp. roundwood															p		
Deciduous timber																	
Alnus sp.				p	43				a		5						
Betula sp.					21			p	a		5				p		
Corylus sp.					14			p	a		5				p		
Fraxinus sp.									a			10					
Pomoideae undiff.												10					
Quercus sp.		10			21		p	p			11		p		p	p	
Salix sp.	p	10			7		p	p			5				p		
Sorbus sp.					7												
Ulmus sp.					7												
Coniferous timber																	
Abies sp.				p													
Coniferae indet.		10										10					
Larix sp.					7		p		a			10		p			
Picea sp.	a	80		a	50		p	p			37		p				
Pinus sp.	p			p	14		p	p	a			10			p	p	

Table 8.3: Archaeobotanical assemblages from Shetland

Block	BU-EIA	KQ-EIA	HH-EIA	SB-EIA	TN-EIA	BB-MIA	HH-MIA	SB-MIA	GU-M/LIA	HH-LIA	SB-LIA
Number of samples (bulk macros)	**10**	n/a	**20**	n/a	n/a	n/a	**170**	n/a	n/a	**235**	n/a
Number of samples (bulk charcoal)	**10**	n/a	**20**	**1**	n/a	n/a	**170**	**4**	n/a	**235**	**4**
Cultivated											
Hordeum vulgare L.	70		5	p	a	p	8	a		14	a
Hordeum sp. naked	60		5	p	p		8	p		8	
Hordeum sp. hulled					a	p	1	a		2	a
Avena sp.							5			9	p
Avena strigosa L.									p		
Linum usitissimum L.										2	
Triticum dicoccum Schubl.	10		5								
Charcoal											
Roundwood											
Alnus sp. roundwood											
Calluna vulgaris (L.) roundwood	60		35	a			34	a	p	79	a
Juniperis sp. roundwood											
Salix sp. roundwood											
Deciduous timber											
Alnus sp.	20						2			1	
Betula sp.	30	p	5				2		p		
Corylus sp.									p	1	
Fraxinus sp.										1	
Hedera helix L.											
Populus sp.									p		
Prunus sp.										1	
Quercus sp.											p
Salix sp.	40		80				62	p	p	33	
Sorbus sp.	10		5				1		p		
Ulmus sp.									p		
Coniferous timber											
Coniferae indet.			5				1			1	p
Larix sp.							1	p			
Picea sp.	10		10				3	p	p	1	p
Pinus sp.		p									p

Table 8.4a: Archaeobotanical assemblages from Orkney

Block	**PO-LIA**	**WB-LIA**	**BBB-LIAII**	**BBC-LIA/N**	**BBA-N**	**BBB-N**	**BBD-N**	**BD-N**	**EB-N**	**PO-N**	**SB-N**	**SV-N**	**TU-N**
Number of samples (bulk macros)	**n/a**	**n/a**	**10**	**34**	**n/a**	**29**	**64**	**n/a**	**n/a**	**n/a**	**n/a**	**10**	**n/a**
Number of samples (bulk charcoal)	**n/a**	**n/a**	**n/a**	**34**	**n/a**	**n/a**	**64**	**n/a**	**n/a**	**n/a**	**8**	**10**	**n/a**
Cultivated													
Hordeum vulgare L.	a	p		100		41	100		p	a	a	20	a
Hordeum sp. naked	p												
Hordeum sp. hulled	a			100		41	100		p	a	a		a
Avena sp.	p		20	91		59	97		a	a	a	20	a
Avena strigosa L.	p					14				p	p	10	
Linum usitissimum L.		p		6			58		p	p	p	20	p
Triticum dicoccum Schubl.													
Charcoal													
Roundwood													
Alnus sp. roundwood								p					
Calluna vulgaris (L.) roundwood			20	15 (a)		7	80		a		a	10	
Juniperis sp. roundwood												10	
Salix sp. roundwood								a					
Deciduous timber													
Alnus sp.			p	p		p	25					20	
Betula sp.			p	p	p	p	50					30	p
Corylus sp.			p		p	p	11				p		
Fraxinus sp.			p			p	5						p
Hedera helix L.			p			p							
Populus sp.													
Prunus sp.													
Quercus sp.				p	p		6						p
Salix sp.			a	9 (a)	a	a	97				p	80	a
Sorbus sp.													
Ulmus sp.													
Coniferous timber													
Coniferae indet.				p			69				p		
Larix sp.													p
Picea sp.			p	p		p					p	30	p
Pinus sp.			p		p	p					p		p

Table 8.4b: Archaeobotanical assemblages from Orkney (continued)

Block	**CK-EIA**	**CY-EIA**	**LA-EIA**	**US-EIA**	**US-MIA**	**CK-MIA**	**LA-M/LIA**	**CK-LIA**	**F-LIAII**	**F-N**	**FC-N**
Number of samples (bulk macros)	**3**	**5**	**n/a**	**20**	**3**	**10**	**n/a**	**0**	**13**	**119**	**n/a**
Number of samples (bulk charcoal)	**3**	**n/a**	**n/a**	**n/a**	**n/a**	**10**	**n/a**	**4**	**81**	**125**	**n/a**
Cultivated											
Hordeum vulgare L.	p	a	a	65	p	50	a		62	77	p
Hordeum sp. naked	p	p	a	a		20	p				
Hordeum sp. hulled		a	p	p			a		62	77	p
Avena sp.	p	p		15	p	20	p		77	72	p
Avena sativa L.									8		
Linum usitissimum L.						10			15	8	
Triticum sp.				5			p			13	
Triticum dicoccum Schubl.		p									
Triticum cf. *aestivum* L.				5						12	
Triticum cf. *spelta* L.		p									
Vicia faba L.										2	
Secale cereale L.		p									
Charcoal											
Roundwood											
Calluna vulgaris (L.) roundwood									53	57	
Juniperis sp. roundwood						10					
Deciduous timber											
Alnus sp.	p					30	p	p	6	5	p
Betula sp.			a			10	a	p	39	19	
Corylus sp.			p			10	a	p			
Populus sp.						20					
Quercus sp.		a					a		2	4	
Salix sp.						10	p		11	7	
Sorbus sp.								p			
Coniferous timber											
Abies sp.											
Coniferae indet.	p					20			2	16	
Pinus sp.	p					20					p

Table 8.5: Archaeobotanical assemblages from Caithness and Sutherland

Block	BA-EIA	CB-EIA	DMV-EIA	AC-MIA	BH-MIA	D-MIA	DMV-MIA	RAD-M/LIA
Number of samples (bulk macros)	**n/a**	**n/a**	**n/a**	**n/a**	**5**	**n/a**	**n/a**	**n/a**
Number of samples (bulk charcoal)	**n/a**	**n/a**	**n/a**	**n/a**	**14**	**n/a**	**n/a**	**n/a**
Cultivated								
Hordeum vulgare L.			a		a	a	a	
Hordeum sp. naked			p			p	p	
Hordeum sp. hulled			a		a	a	a	
Avena sp.					p	p		
Triticum sp.						p		
Triticum dicoccum Schubl.					p	p		
Charcoal / uncarbonised wood								
Roundwood								
Alnus sp. roundwood						a		
Bark roundwood								
Betula sp. roundwood						a		
Calluna vulgaris (L.) roundwood								
Corylus sp. roundwood					36	a		
Fraxinus sp. roundwood								
Ilex aquifolium L.								
Quercus sp. roundwood						a		
Salix sp. roundwood					7		p	
Sorbus sp. roundwood								
Deciduous timber								
Alnus sp.	p	a		p	7		p	
Betula sp.		p						p
Corylus sp.	a	a	p	p	64		p	
Fraxinus sp.								
Hedera helix L.								
Pomoideae undiff.								p
Populus sp.								
Prunus sp.								
Quercus sp.	a	p		p	14		p	p
Salix sp.	p	p	p		21		p	p
Ulmus sp.	p							
Coniferous timber								
Coniferae indet.					14			
Picea sp.	p						p	
Pinus sp.								p

Table 8.6a: Archaeobotanical assemblages from Argyll, Inner Hebrides and Skye

Block	D-LIA	DB-LIA	KB-LIA	MA-LIAI	AR-LIAI	IO-LIAII	MA-LIAII
Number of samples (bulk macros)	n/a	n/a	n/a	n/a	n/a	5	2
Number of samples (bulk charcoal)	n/a	n/a	n/a	n/a	2	n/a	2
Cultivated							
Hordeum vulgare L.	a						p
Hordeum sp. naked	p						
Hordeum sp. hulled	a			p			p
Avena sp.	a	a					p
Triticum sp.	p						
Triticum dicoccum Schubl.	p						
Charcoal / uncarbonised wood							
Roundwood							
Alnus sp. Roundwood	a					a	
Bark roundwood						a	
Betula sp. roundwood	a						
Calluna vulgaris (L.) roundwood						a	p
Corylus sp. roundwood	a					a	
Fraxinus sp. roundwood	p						
Ilex aquifolium L.	p						
Quercus sp. roundwood	a						
Salix sp. roundwood							
Sorbus sp. roundwood	p						
Deciduous timber							
Alnus sp.				p		a	
Betula sp.			p	p	p	a	
Corylus sp.			p	p	p	a	
Fraxinus sp.			p			p	p
Hedera helix L.						p	
Pomoideae undiff.							
Populus sp.						p	
Prunus sp.					p	p	
Quercus sp.			p	p		a	
Salix sp.			p		p	p	
Ulmus sp.							
Coniferous timber							
Coniferae indet.							
Picea sp.					p		
Pinus sp.						p	

Table 8.6b: Archaeobotanical assemblages from Argyll, Inner Hebrides and Skye (continued)

Period	Block	Number of samples	Barley %	Flax %	Oat %	Rye %	Wheat %	Barley U	Flax U	Oat U	Rye U	Wheat U
EIA	GE	18	100	0	0	0	0	100	0	0	0	0
EIA	DV-EIA	1	100	0	0	0	0	100	0	0	0	0
MIA	DB-P	1	100	0	0	0	0	100	0	0	0	0
MIA	DB-S	1	100	0	0	0	0	100	0	0	0	0
MIA	GUN-IA	12	62	0	38	0	0	75	0	33	0	0
MIA	CN-W	3	100	0	0	0	0	100	0	0	0	0
MIA	CN-C	1	100	0	0	0	0	100	0	0	0	0
MIA	CN-R	4	100	0	0	0	0	75	0	0	0	0
MIA	AC T17	7	100	0	0	0	0	86	0	0	0	0
MIA	DV-MIA	81	99.8	0	0.1	0	0.1	95	0	2	0	4
MIA	KD-MIA	18	100	0	0	0	0	89	0	0	0	0
LIA-I	LB-R	1	95	3	2	0	0	100	100	100	0	0
LIA-I	LB-C	20	99.5	0.2	0.1	0	0.2	100	10	15	0	5
LIA-I	GAL-LIA	2	100	0	0	0	0	100	0	0	0	0
LIA-I	BO-E	1	100	0	0	0	0	100	0	0	0	0
LIA I	DV-LIA I	23	99.8	0	0.1	0	0.1	91	0	13	0	4
LIA-II	BO-LIA	80	88	10.3	1.3	0.1	0.4	96	39	43	1	16
LIA-II	LB-LIA	4	71	25	3	0	1	100	50	25	0	25
LIA II	DV-LIA II	23	100	0	0	0	0	96	0	0	0	0
LIA/N	BO-LIA/N	26	94.7	0.3	4.6	0	0.4	100	15	42	0	19
N/EM	BARV	27	71	2	27	0	0	100	43	96	0	0
N/EM	BO-N	11	72.2	0.9	26.3	0.2	0.3	100	36	73	18	18
N/EM	GAL-N/M	10	79.9	0.1	19.7	0.1	0.2	100	10	80	10	30

Table 8.7: Proportions and Ubiquity scores for cultivated genera from all blocks of analysis in the Western Isles

Block	K-MIA	SC-MIA	K-LIAI	SC-LIAI	SC-LIAII	BU-EIA	BBC-LIAII/N	BBB-N	SV-N	CY-EIA	US-EIA	F-LIAII	F-N	DMV
Area	**Shet**	**Shet**	**Shet**	**Shet**	**Shet**	**Ork**	**Ork**	**Ork**	**Ork**	**C & S**	**C & S**	**C & S**	**C & S**	**A, IH & S**
Number of bulk samples	**14**	**23**	**19**	**20**	**44**	**10**	**34**	**29**	**10**	**5**	**20**	**13**	**119**	**1**
Hordeum sp.											265 (88.3%)			
Symmetric:asymmetric ratio											1:0.97			
Hordeum vulgare L.	247 (85.2%)	1084 (97%)	1362 (76.8)	1133 (96.3%)	1798 (87.8%)	106 (98.1%)	6952 (88.8%)	41 (18.9%)	61 (32.6%)	3057 (98.2%)		81 (48.5%)	2327 (54.8%)	290 (100)
Hordeum sp. naked	6 (2.1%)	5 (0.4%)	2 (0.1%)	6 (0.5%)	1 (0.1%)	26 (24.1%)				282 (9.1%)	100 (33.3%)			28 (9.7%)
Naked symmetric:asymmetric ratio										1:1.59				
Hordeum sp. hulled	15 (5.2%)	1084 (97%)	119 (6.7%)	1133 (96.3%)	1798 (87.8%)		6952 (88.8%)	41 (18.9%)	61 (32.6%)	2707 (87.1%)	5 (1.7%)	81 (48.5%)		262 (90.3%)
Hulled symmetric:asymmetric ratio		1:2.24		1:2.25	1:2.48					1:2.32				
Avena sp.	43 (14.8%)	28 (2.5%)	406 (22.8%)		240 (11.7%)		871 (11.1%)	176 (81.1%)	24 (12.8%)	11 (0.4%)	28 (9.4%)	84 (50.3%)	1865 (43.9%)	
Avena sativa L.														
Linum usitissimum L.			5 (0.4%)		9 (0.4%)		4 (0.1%)		102 (54.5%)			2 (1.2%)	19 (0.4%)	
Triticum sp.											7 (2.3%)		16 (0.4%	
Triticum dicoccum Schubl.						2 (1.9%)				37 (1.2%)				
Triticum cf. *aestivum* L.													17 (0.4%)	
Triticum cf. *spelta* L.										3 (0.1%)				
Vicia faba L.													2 (0.1%)	
Secale cereale L.														
Total seed/grain	**290**	**1117**	**1773**	**1176**	**2048**	**108**	**7827**	**217**	**187**	**3109**	**300**	**167**	**4246**	**290**

*Excluding grain from conflagration level

Table 8.8: Proportions of cultivated species and genera for blocks in Atlantic Scotland with greater than 100 seeds/grain

Area	Shetland		Orkney	
Number of blocks with charcoal	**13**		**19**	
Number of genera/species	**15**		**16**	
Presence/abundance	**p/(U<50%)**	**a/(U>50%)**	**p/(U<50%)**	**a/(U>50%)**
Roundwood				
Alnus sp. roundwood			1/19 (5%)	
Betula sp. roundwood				
Calluna vulgaris (L.) roundwood	10/13 (77%)	7/10 (54%)	15/19 (79%)	9/19 (47%)
Corylus sp. roundwood				
Fraxinus sp. roundwood				
Juniperis sp. roundwood	1/13 (8%)		1/19 (5%)	
Hedera helix L. roundwood			2/19 (11%)	
Ilex aquifolium L. roundwood				
Quercus sp. roundwood				
Salix sp. roundwood			1/19 (5%)	1/19 (5%)
Sorbus sp. roundwood				
Deciduous timber				
Alnus sp.	4/13 (31%)	1/13 (8%)	8/19 (42%)	
Betula sp.	5/13 (38%)	1/13 (8%)	12/19 (63%)	1/19 (5%)
Corylus sp.	5/13 (38%)	1/13 (8%)	7/19 (37%)	
Fraxinus sp.	2/13 (15%)	1/13 (8%)	5/19 (26%)	
Pomoideae undiff.	1/13 (8%)			
Populus sp.			1/19 (5%)	
Prunus sp.			1/19 (5%)	
Quercus sp.	8/13 (62%)		5/19 (26%)	
Salix sp.	7/13 (54%)		14/19 (74%)	9/19 (47%)
Sorbus sp.	1/13 (8%)		4/19 (21%)	
Ulmus sp.	1/13 (8%)		1/19 (5%)	
Coniferous timber				
Abies sp.	1/13 (8%)			
Coniferae indet.	2/13 (15%)		7/19 (37%)	1/19 (5%)
Larix sp.	5/13 (38%)	1/13 (8%)	3/19 (16%)	
Picea sp.	8/13 (62%)	3/13 (23%)	13/19 (68%)	
Pinus sp.	9/13 (69%)	1/13 (8%)	7/19 (37%)	

Table 8.9a: Ubiquity scores for charcoal genera / species per area in Atlantic Scotland

Area	Caithness & Sutherland		Argyll, Inner Hebrides & Skye	
Number of blocks with charcoal	**9**		**12**	
Number of genera/species	**11**		**16**	
Presence/abundance	**p/(U<50%)**	**a/(U>50%)**	**p/(U<50%)**	**a/(U>50%)**
Roundwood				
Alnus sp. roundwood			3/12 (25%)	3/12 (25%)
Betula sp. roundwood			2/12 (17%)	2/12 (17%)
Calluna vulgaris (L.) roundwood	2/9 (22%)	2/9 (22%)	2/12 (17%)	1/12 (8%)
Corylus sp. roundwood			4/12 (33%)	3/12 (25%)
Fraxinus sp. roundwood			1/12 (8%)	
Juniperis sp. roundwood	1/9 (11%)			
Hedera helix L. roundwood				
Ilex aquifolium L. roundwood			1/12 (8%)	
Quercus sp. roundwood			2/12 (17%)	2/12 (17%)
Salix sp. roundwood			2/12 (17%)	
Sorbus sp. roundwood			1/12 (8%)	
Deciduous timber				
Alnus sp.	7/9 (78%)		7/12 (58%)	2/12 (17%)
Betula sp.	6/9 (67%)	2/9 (22%)	6/12 (50%)	1/12 (8%)
Corylus sp.	4/9 (44%)	1/9 (11%)	10/12 (83%)	4/12 (33%)
Fraxinus sp.			3/12 (25%)	
Pomoideae undiff.			1/12 (8%)	
Populus sp.				
Prunus sp.				
Quercus sp.	4/9 (44%)	2/9 (22%)	9/12 (75%)	2/12 (17%)
Salix sp.	4/9 (44%)		9/12 (75%)	
Sorbus sp.	1/9 (11%)			
Ulmus sp.			1/12 (8%)	
Coniferous timber				
Abies sp.				
Coniferae indet.	4/9 (44%)		1/12 (8%)	
Larix sp.				
Picea sp.			3/12 (25%)	
Pinus sp.	3/9 (33%)		2/12 (17%)	

Table 8.9b: Ubiquity scores for charcoal and wood genera / species per area in Atlantic Scotland

Site	Archaeological information	Palaeoenvironmental information
Shetland		
Scalloway (Sharples, 1998)	Conflagration of secondary occupation of Atlantic roundhouse.	Soil micromorphology (Carter, 1998b)
Orkney		
Howe (Ballin-Smith, 1994)	1) Early Phase 7 – SW building roof fire 2) Early Phase 7 – NW building roof fire 3) Early Phase 7 – E building *in situ* posts 4) Early Phase 7 – 'Broch 2' secondary occupation fire 5) Late Phase 7 – 'Broch 2' secondary occupation roof fire 6) Late Phase 7 – 'Broch 2' secondary occupation fire	Archaeobotany (Dickson, 1994) 1) Timbers (willow, spruce), six-row naked barley/heather mixed thatch, *in situ* floor level material 2) Closure episode (?), timbers (willow, spruce), six-row naked barley thatch 3) Uncarbonised alder posts 4) Six-row naked barley straw (stored or on floor) 5) Roof timbers (willow and spruce) 6) Six-row naked barley crop processing accident leading to fire, roof timbers (willow)
Western Isles		
Dun Vulan (Parker-Pearson & Sharples, 1999)	Waterlogged level of Early Iron Age date	Hazel, larch and alder woodworking chippings (Taylor, 1999)
Beirgh (Harding & Gilmour, 2000)	Primary Cellular *in situ* uncarbonised structural material	Archaeobotany (Church, forthcoming) • Spruce post • Coppiced hazel wattlework
Dun Bharabhat (Harding & Dixon, 2000)	Secondary occupation conflagration	Archaeobotany (Church, 2000) • Timber (spruce, Scot's Pine) • Six-row and two-row hulled barley thatch
Bornais (Sharples, 2000)	Probable wheelhouse conflagration	Post-ex ongoing
Inner Hebrides		
Dun Ardtreck (Mackie, 2000)	1) Iron Age conflagration 2) Medieval (?) conflagration	None
Dun Mor Vaul (Mackie, 1974)	Possible early Iron Age conflagration	Archaeobotany (Renfrew, 1974) • Carbonised post (indet.) • Six-row hulled barley cache
Argyll		
Rahoy (Childe & Thorneycroft, 1938)	1) Vitrified walling in 'fort' 2) *In situ* interior posts	1) Hazel timber 2) Oak
Iona (Barber, 1981)	Waterlogged ditch of LIA-II date	Multiple species of deciduous roundwood and timber (Barber, 1981; Fairweather, 1981)
Sutherland		
Cyderhall (Pollock, 1992)	Souterrain roof fire	Oak branchwood (Boardman, 1992)
Langwell (Nisbet, 1995)	Atlantic Roundhouse roof fire	None

Table 8.10: Conflagration levels and waterlogged remains of the first millennia in Atlantic Scotland

Appendix A: Flot recovery efficiency

Research aim:

To test the recovery rate of carbonised plant macrofossils within the flots from the various sites, in order to form efficient sorting strategies for each site.

Methodology:

Once all the flots were sorted, a random selection of residues was chosen for further sorting (20% of the total residue population). When a residue was large, a 50, 25 or 12.5 % sub-sample of the 2R and 1R fractions was separated using a riffle box to ensure statistical representation (van der Veen & Feiller, 1982). The grain counts for the flots and residues were then compared, with adjusted grain totals calculated for the residue if sub-sampling had taken place. Therefore, some of the grain totals for the residues are adjusted figures, rather than the actual number of grains recovered. Grains were chosen as the parameter of flot efficiency as they were one of the most numerous and ubiquitous classes of archaeobotanical material across the sites and were easily quantified. Only samples with greater that 10 cereal grains were chosen for this exercise, as lower numbers would create unrepresentative percentages. The percentage of grain in the flot and residue for each sample were then calculated, followed by the flot efficiency of the site as a whole. This was based on the average flot and residue recovery from all the samples. Three of the sites (Calanais kerb cairn, Cnip and Dun Bharabhat) were not part of this exercise as the flots and residues from all three sites had already been sorted.

Results:

Table A1 shows the recovery rates from six of the sites chosen for this recovery test. Five of the six sites had flot recovery rates over 80% with three of the sites over 90%. Tables A2-7 display the results from each of the six sites. Neither soil moisture content nor organic content of the soil matrix seemed to make any difference to the flot recovery. Therefore, the general sorting strategy was to sort the flot fractions in their entirety and the residue fractions from the sites in the machair (Bostadh, Galson and Loch na Beirgh) that had good bone and shell preservation present in the residues. The flot recovery results from these three sites include all the samples sorted, not just the 20% random sample. The 20% random samples are shown for An Dunan and Guinnerso and their high values of flot recovery meant no further sorting of the 2R and 1R fractions was undertaken. An exception to this rule was Gob Eirer, where total sorting of all the fractions was required. The flot recovery was very low (8%) due to the complex post-depositional soil processes on the site. Widespread podsolization and leaching meant that much of the carbonised material had filtered and crystallised the mobile ferrous oxides, making the macrofossils much more dense than normal. This meant that the macrofossils were unlikely to float off and remained in the residues.

Site	Soil type and landscape setting	Soil moisture	Soil organic content (% mean)	Average flot recovery (% of total caryopses in flot)	Number of samples with greater than 10 caryopses
An Dunan	Friable sandy silt on islet in estuarine saltings	Damp	10.9	94.5	3
Bostadh	Light sand within machair	Dry	3.5	85.9	114
Galson	Light sand within machair	Dry	5.1	92.2	9
Gob Eirer	Heavy clayey silt on promontory stack	Wet	12.93	8.0	15
Guinnerso	Heavy sandy silt within moorland	Damp to wet	15.3	100	3
Loch na Beirgh	Seasonally to permanent waterlogged sandy silt within machair slack	Wet to waterlogged	11.7	82.2	37

Table A1: Recovery efficiency of archaeobotanical material (Recovery Test 2)

Sample	Context	Flot (Grain total)	Residue (Adjusted grain total)	Total grain	Flot (%)	Residue (%)	2R sorting
37	45	51	10	61	83.61	16.39	50
47	67	24		24	100.00	0.00	100
110	152	26		26	100.00	0.00	25
	Totals	**101 (91.0%)**	**10 (9.0%)**	**111**	**94.5**	**5.5**	

Table A2: Flot recovery efficiency from An Dunan

Sample	Context	Flot (Grain total)	Residue (Adjusted grain total)	Total grain	Flot (%)	Residue (%)	2R sorting
8	20	6	5	11	54.55	45.45	100
22	50	13		13	100.00	0.00	100
26/27	53	400	6	406	98.52	1.48	100
30	56	18	6	24	75.00	25.00	100
32	58	40	7	47	85.11	14.89	100
33	60	24		24	100.00	0.00	100
34	60	68	9	77	88.31	11.69	100
36	64	768		768	100.00	0.00	100
39	53	87	40	127	68.50	31.50	100
56	149	12		12	100.00	0.00	100
57	123	121	18	139	87.05	12.95	100
72	96	15		15	100.00	0.00	100
74	39	72	63	135	53.33	46.67	100
78	59	22	1	23	95.65	4.35	100
86	19	58		58	100.00	0.00	100
87	33	180	116	296	60.81	39.19	100
91	174	32	1	33	96.97	3.03	100
92	99	44	9	53	83.02	16.98	100
93	101	25	4	29	86.21	13.79	100
97	102	19	1	20	95.00	5.00	100
98	103	11		11	100.00	0.00	100

101	200	20	3	23	86.96	13.04	100
107	107	390	44	434	89.86	10.14	100
108	205	12	1	13	92.31	7.69	100
111	98	13	1	14	92.86	7.14	100
122	214	43	2	45	95.56	4.44	100
124.1	173	53	13	66	80.30	19.70	100
124.2	114	20	4	24	83.33	16.67	100
128	164	51		51	100.00	0.00	100
129	120	15		15	100.00	0.00	100
130	248	26	2	28	92.86	7.14	100
131	280	20	2	22	90.91	9.09	100
132	282	23		23	100.00	0.00	100
133	249	574	70	644	89.13	10.87	100
135	284	12	1	13	92.31	7.69	100
136	148	166	16	182	91.21	8.79	100
137	285	34	6	40	85.00	15.00	100
140	112	609	34	643	94.71	5.29	100
143	250	2	13	15	13.33	86.67	100
150	230	10		10	100.00	0.00	100
151	221	65	18	83	78.31	21.69	100
155	261	957	141	1098	87.16	12.84	100
156	264	12		12	100.00	0.00	100
158	263	34		34	100.00	0.00	100
166	317		10	10	0.00	100.00	100
170.1	318a	1116	420	1536	72.66	27.34	100
170.2	318b	20		20	100.00	0.00	100
176	358	17		17	100.00	0.00	100
177	319	22		22	100.00	0.00	100
181	431	84		84	100.00	0.00	100
185	432	105	2	107	98.13	1.87	100
186	435	10		10	100.00	0.00	100
189	623	10		10	100.00	0.00	100
196	379	25	4	29	86.21	13.79	100
198	464	16	5	21	76.19	23.81	100
205	441	47	4	51	92.16	7.84	50
206	285	209	36	245	85.31	14.69	100
208	443	50		50	100.00	0.00	100
209	454	31	32	63	49.21	50.79	100
210	461	169	2	171	98.83	1.17	100
211	287	32		32	100.00	0.00	100
221	518	8	2	10	80.00	20.00	100
232	481	20		20	100.00	0.00	100
240	650	14		14	100.00	0.00	100
242	33	165		165	100.00	0.00	100
245	535	25	2	27	92.59	7.41	100
247	537	15		15	100.00	0.00	100
248	471	17	1	18	94.44	5.56	100
249	466	60	3	63	95.24	4.76	100
250	493	14		14	100.00	0.00	100
251	471	16	2	18	88.89	11.11	100
258	707	30	1	31	96.77	3.23	100
261	714	135		135	100.00	0.00	100
263	363	27		27	100.00	0.00	100
274	523/519	13		13	100.00	0.00	100
276	575	53	13	66	80.30	19.70	100
277	574	216		216	100.00	0.00	100

279	583	20	2	22	90.91	9.09	100
280	581	68	5	73	93.15	6.85	100
281	570	11		11	100.00	0.00	100
282	584	38	6	44	86.36	13.64	100
283	624	590	28	618	95.47	4.53	100
284	714	333	58	391	85.17	14.83	100
286	862	44	12	56	78.57	21.43	100
287	362	196	100	296	66.22	33.78	100
288	742	11	5	16	68.75	31.25	100
289	354	89	11	100	89.00	11.00	100
290	863	334	170	504	66.27	33.73	100
291	866	141	134	275	51.27	48.73	100
292	867	8	21	29	27.59	72.41	100
293	868	36		36	100.00	0.00	100
297	717	11	1	12	91.67	8.33	100
298	744	1073	26	1099	97.63	2.37	100
299	748	830	300	1130	73.45	26.55	100
300	743	912	231	1143	79.79	20.21	100
308	879	11		11	100.00	0.00	100
309	884	21	11	32	65.63	34.38	100
311	586	38	3	41	92.68	7.32	100
313	885/2	39		39	100.00	0.00	100
317	885/3	42	8	50	84.00	16.00	100
318	887	13	7	20	65.00	35.00	100
319	891	3	10	13	23.08	76.92	100
320	889	30	3	33	90.91	9.09	100
323	885/6	525	17	542	96.86	3.14	100
324	885/7	108	15	123	87.80	12.20	100
325	738	138	86	224	61.61	38.39	100
326	753	483	210	693	69.70	30.30	100
327	751	238	77	315	75.56	24.44	100
328	890	42	9	51	82.35	17.65	100
330	749	136	78	214	63.55	36.45	100
331	888	45	21	66	68.18	31.82	100
Not given	288	94	9	103	91.26	8.74	100
Not given	314	14		14	100.00	0.00	100
Not given	315	214	59	273	78.39	21.61	100
		14966 (83.6%)	**2929 (16.4%)**	**17895**	**85.9**	**14.1**	

Table A3: Flot recovery efficiency from Bostadh

Sample	**Context**	**Flot (Grain total)**	**Residue (Adjusted grain total)**	**Total grain**	**Flot (%)**	**Residue (%)**	**2R sorted (%)**
2	B/1	1365	250	1615	84.52	15.48	100
3	B/2	13	1	14	92.86	7.14	100
13	B/22	10		10	100.00	0.00	100
15	B/24	24	8	32	75.00	25.00	100
52	150	11	1	12	91.67	8.33	100
53	151	9	1	10	90.00	10.00	100
55	114	61		61	100.00	0.00	100
57	131	24	1	25	96.00	4.00	100
59	200	30		30	100.00	0.00	100
	Totals	**1547 (85.5%)**	**262 (14.5%)**	**1809**	**92.2**	**7.8**	

Table A4: Flot recovery efficiency from Galson

Sample	Context	Flot (Grain total)	Residue (Adjusted grain total)	Total grain	Flot (%)	Residue (%)	2R sorted
5	8	0	12	12	0.00	100.00	100
10	14	3	12	15	20.00	80.00	100
12	28	5	35	40	12.50	87.50	100
14	30	1	54	55	1.82	98.18	100
16	35	0	58	58	0.00	100.00	100
18	41	0	21	21	0.00	100.00	100
21	44	0	36	36	0.00	100.00	100
23	47	3	13	16	18.75	81.25	100
34	69	2	27	29	6.90	93.10	100
35	82	0	23	23	0.00	100.00	100
37	85	1	40	41	2.44	97.56	100
39	42	1	9	10	10.00	90.00	100
41	87	6	20	26	23.08	76.92	100
44	94	0	10	10	0.00	100.00	100
45	95	5	15	20	25.00	75.00	100
		27 (6.6%)	**385 (93.4%)**	**412**	**8.03**	**91.97**	

Table A5: Flot recovery efficiency from Gob Eirer

Sample	Context	Flot (Grain total)	Residue (Adjusted grain total)	Total grain	Flot (%)	Residue (%)	2R sorting
253	373	12	0	12	100.0	0.0	100
272	397	21	0	21	100.0	0.0	100
		33 (100%)	**0 (0%)**	**33**	**100.0**	**0.0**	

Table A6: Flot recovery efficiency from Guinnerso

Sample	Context	Flot (Grain total)	Residue (Adjusted grain total)	Total grain	Flot (%)	Residue (%)	2R sorting
86/2	10	16		16	100.00	0.00	50
86/5	11?	30		30	100.00	0.00	100
87/2	83	82		82	100.00	0.00	100
87/5	58	14		14	100.00	0.00	100
89/3	246	75		75	100.00	0.00	100
94/10	458	13	20	33	39.39	60.61	25
204	469	15		15	100.00	0.00	100
213	486	18	32	50	36.00	64.00	12.5
215	487	8		8	100.00	0.00	12.5
216	174	20		20	100.00	0.00	12.5
218	485	307	152	459	66.88	33.12	12.5
219	491	15		15	100.00	0.00	12.5
223	498	13		13	100.00	0.00	25
229	503	521	228	749	69.56	30.44	25
230	462	22	8	30	73.33	26.67	50
236	507	32		32	100.00	0.00	12.5
237	501	35		35	100.00	0.00	50
240	509	13		13	100.00	0.00	100
241	515	11		11	100.00	0.00	25
248	511	15	20	35	42.86	57.14	25
257	522	18		18	100.00	0.00	50
265	531	14	4	18	77.78	22.22	25
266	518	12	4	16	75.00	25.00	100
294	539	34	4	38	89.47	10.53	25
295	540	11	9	20	55.00	45.00	100
305	541	69	64	133	51.88	48.12	12.5
319	452	32		32	100.00	0.00	12.5
322	552	17	15	32	53.13	46.88	100
325	555	39	23	62	62.90	37.10	87.5
344	559	58	16	74	78.38	21.62	12.5
345	567	13		13	100.00	0.00	25
354	574	64		64	100.00	0.00	25
361	577	14		14	100.00	0.00	100
366	580	200	50	250	80.00	20.00	50
367	583	7	12	19	36.84	63.16	25
374	553	46	32	78	58.97	41.03	25
379	578	15	1	16	93.75	6.25	100
	Totals	**1938 (73.6%)**	**694 (26.4)**	**2632**	**82.2**	**17.8**	

Table A7: Flot recovery efficiency from Loch na Beirgh

Appendix B: Carbonised macrofossil and charcoal identifications from samples

The identifications are presented in tabular form by sample, with the macrofossils presented first in block chronological order and the charcoal presented by site chronological order.

Key to plant parts for carbonised macrofossils:

Grain

(C) = caryopsis

(S) = seed

Chaff

(AF) = awn fragment

(BRI) = basal rachis internode

(CB) = culm base (greater than 2mm in diameter)

(CN) = culm node (greater than 2mm in diameter)

(FB) = floret base

(RI) = rachis internode

(SLS) = sterile lateral spikelet

Wild

(A) = achene

(C) = caryopsis

(F) = fruit

(Cap) = capsule

(CapB) = capsule base

(CB) = culm base (less than 2mm in diameter)

(CN) = culm node (less than 2mm in diameter)

(FB/Sp) = floret base/spikelet

(LF) = leaf fragment

(N) = nutlet

(NF) = nutshell fragment

(P) = pericarp

(R) = rhizome (greater and less than 2mm in diameter)

(S) = seed

Context	121	122	129	134	135	137	177	180	181ds	181ws	182ds	182ws	
Block	CC-3	CC-3	CC-3	CC-3	CC-3	CC-3	CC-3	CC-3	CC-3	CC-3	CC-3	CC-3	
Context type	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	
Volume (litres)	43	17	13	5	22	10	11	17	10	18	10	16	**Totals**
Hordeum sp. (C)	7	4	1		42	1	5	39	27	9	5	4	144
H. naked (C)	1		1		1		1	2	2			1	9
H. cf. naked (C)	2	1			11			2		1			17
H. naked symmetric (C)		1			1			2		1			5
H. naked asymmetric (C)		2			2			2					6
H. hulled (C)	9	1			37		6	17	7	8			85
H. cf. hulled (C)	5	2			8			11	2				28
H. hulled symmetric (C)	1				7			2			1	1	12
H. hulled asymmetric (C)	3				12			5	1	1		2	24
Avena sp. (C)		3						1					4
Triticum sp. (C)		1			1								2
Cereal indeterminate (C)	7	4	2		24	1	6	25	27	3	3	1	103
Total grain	35	19	4	0	146	2	18	108	66	23	9	9	439
Cereal indeterminate (AF)	1												1
Cereal/monocotyledon (>2 mm.) (CN)					4			1					5
Cereal/monocotyledon (>2 mm.) (CB)	10	4		8	6	6	2	9	9	10		5	69
Total chaff	11	4	0	8	10	6	2	10	9	10	0	5	75
Atriplex hastata L. (S)	3												3
Brassica cf. *rapa* L. (S)	7	2	2	3	19	1	3	9	10	180	50	30	316
Brassica/Sinapis spp. (S)	10	1	3	4	16		6	21	2	33	25	8	129
Calluna vulgaris (L.) Hull. (S)	1												1
Calluna vulgaris (L.) Hull. (Cap)	2	1			1	2		2	1				9
Calluna vulgaris (L.) Hull. (LF)								1F					0
Carex spp. (biconvex) (N)	19	6		17	11		1	2	2	2		1	61
Carex spp. (trigonous) (N)	29	11	2	22	11	2	5	11	2	2	2	2	101
Chenopodium/Atriplex spp. (S)	2	4	1	1	2	1	1		1				13
Chrysanthemum segetum L. (A)	1												1
Danthonia decumbens L. (C)	8	1		6	3		1	5	2	3		1	30
Erica/Calluna spp. (Cap)	5	6	1	2	1			2		1	1		19
Galeopsis tetrahit L. (N)	1	1											2
Montia fontana L. (S)	2												2
Persicaria maculosa Gray (N)		1											1
Persicaria lapathifolia (L.) Gray (N)		1											1
Plantago lanceolata L. (S)	8	1	1	3	5	1	3	7	2	4	1	4	40
Poaceae undiff. (medium) (C)	3	2	1		2		1	1	1		2		13
Poa cf. *annua* L. (C)	2				2								4
Poaceae undiff. (small) (C)	2	3	1			1		1					8
Polygonum spp. (N)	2	2	1	4	4		1	3				1	18
Polygonum aviculare L. (N)	4								1	2			7
Ranunculus spp. (A)	3	1			1		1			2			8
Ranunculus repens L. (A)		1	2				1	5					9
Raphanus raphanistrum L. (F)	2									1			3
Rumex acetosa L. (N)										1			1
Rumex acetosella L. (N)	3							2		20	6	4	35
Rumex crispus L. (N)	12	3			5	1	4	3	1	5	4	2	40
Rumex spp. (N)		1			1					1		3	6
Sorbus sp. (S)				1									1
Spergula arvensis L. (S)		6											6
Stachys spp. (F)	1												1
Stachys cf. *palustris* L. (F)	4	5			3				1	1			14
Stellaria media (L.) Villars (S)	6	14	3	7	3			1					34
Urtica dioica L. (F)											1		1
Urtica urens L. (F)		1											1
Vaccinium myrtillus L. (S)		2										1	3
Vaccinium vitis-idaea L. (S)	1	2	1										4
cf. *Vicia/Lathyrus* spp. (S)	1												1
Cereal/monocotyledon (<2 mm.) (CN)	13		1	17	14	9	4	30	17	9	3	4	121
Cereal/monocotyledon (<2 mm.) (CB)	25	3	6	28	10	10	10	31	17	29	1	8	178
Indeterminate (>2 mm.) (R)	1	2		5	5			6	5	3	5	1	33
Indeterminate (<2 mm.) (R)	42	1		4	2	3	1	19	7	12	1	4	96
Indeterminate seed/fruit (S/F)	14	2	1	5	4	2	2	5	8	6	7	6	62
Indeterminate pericarp fragment (P)								1					1
Total wild	239	87	27	129	125	33	45	167	80	317	109	80	1438
Total QC	285	110	31	137	281	41	65	285	155	350	118	94	
QC/litre	6.63	6.47	2.38	27.40	12.77	4.10	5.91	16.76	15.50	19.44	11.80	5.88	
caryopsis/litre	0.8	1.1	0.3	0.0	6.6	0.2	1.6	6.4	6.6	1.3	0.9	0.6	
% grain	12.3	17.3	12.9	0.0	52.0	4.9	27.7	37.9	42.6	6.6	7.6	9.6	
% chaff	4.6	4.6	0.0	6.2	8.0	18.2	4.4	6.0	11.3	3.2	0.0	6.3	
% wild	83.9	79.1	87.1	94.2	44.5	80.5	69.2	58.6	51.6	90.6	92.4	85.1	

Table B1: Macrofossil counts for Calanais kerb cairn (**CC-3**)

Sample	5	10	11	12	13	14	16	18	19	20	21	23	35	37	39	44	45	49	
Context	8	14	25	28	29	30	35	41	42	43	44	47	82	85	92	94	95	97	
Block	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	
Context type	OL	OL	OL	OL	OL	OL	NFF	OL	OL	OL	OL	NFF	OL	OL	FL	AS	FL	FL	
Volume (litres)	28	28	28	28	28	28	56	28	28	28	42	56	28	28	14	14	56	28	**Total**
Grain																			
Hordeum sp. (C)	4	4	1	6	1	13	16	8		2	19	3	11	20	3	1	9		121
H. naked (C)				1										1			1		3
H. cf. naked (C)	1					1	1				1			1	1		1		7
H. naked asymmetric (C)											1								1
H. hulled (C)	2	3	1	21		16	12	2		2	5	7	3	7	5	4	6	4	100
H. cf. hulled (C)		2		7	3	7	12	1	1	3	5	3	5	3	1	1	1	1	56
H. hulled symmetric (C)	1			2		1	1	2				1		2		1	1	1	13
H. hulled asymmetric (C)	1	1		1		3		1			1		2	1		3	1	2	17
Cereal indeterminate (C)	3	5		2	1	14	16	7		1	4	2	2	6				1	64
Grain total	12	15	2	40	5	55	58	21	1	8	36	16	23	41	10	10	20	9	382
Chaff																			
H. *vulgare* L. (RI)				1		2											2		5
Cereal/monocotyledon (>2 mm.) (CN)	2				1						2		1				2		8
Cereal/monocotyledon (>2 mm.) (CB)	1			3	1	4		1	2	1	7	4		1			14	1	40
Chaff total	3	0	0	4	2	6	0	1	2	1	9	4	1	1	0	0	18	1	53
Wild species																			
Brassica/Sinapis spp. (S)					1	1													2
Carex spp. (biconvex) (N)												1							1
Carex spp. (trigonous) (N)												1							1
Chrysanthemum segetum L. (A)	1																		1
Corylus avellana L. (NF)																		1F	0
Plantago lanceolata L. (S)		3		1															4
Poaceae undiff. (medium) (C)				1															1
Polygonum aviculare L. (N)						1													1
Rumex acetosella L. (N)		1																	1
Sorbus aucuparia L. (S)																1			1
Cereal/monocotyledon (<2 mm.) (CN)																	5		5
Cereal/monocotyledon (<2 mm.) (CB)				5		2	1	1	5		2	1			2		21	2	42
Indeterminate (>2 mm.) (R)	3		3	3		2	4		9	3	7	4	1	1	2	1	11	4	58
Indeterminate (<2 mm.) (R)				2					4		3	4	1	2			10		26
Indeterminate seed/fruit (S/F)				3			1						1						5
Wild total	4	4	3	15	1	6	6	1	18	3	12	11	3	3	4	2	47	6	149
Total QC	19	19	5	59	8	67	64	23	21	12	57	31	27	45	14	12	85	16	
QC/litre	0.7	0.7	0.2	2.1	0.3	2.4	1.1	0.8	0.8	0.4	1.4	0.6	1.0	1.6	1.0	0.9	1.5	0.6	
caryopsis/litre	0.4	0.5	0.1	1.4	0.2	2.0	1.0	0.8	0.0	0.3	0.9	0.3	0.8	1.5	0.7	0.7	0.4	0.3	
% grain	63.2	78.9	40.0	67.8	62.5	82.1	90.6	91.3	4.8	66.7	63.2	51.6	85.2	91.1	71.4	83.3	23.5	56.3	
% chaff	15.8	0.0	0.0	6.8	25.0	9.0	0.0	4.3	9.5	8.3	15.8	12.9	3.7	2.2	0.0	0.0	21.2	6.3	
% wild	21.1	21.1	60.0	25.4	12.5	9.0	9.4	4.3	85.7	25.0	21.1	35.5	11.1	6.7	28.6	16.7	55.3	37.5	

Table B2: Macrofossil counts for Gob Eirer (**GE**)

Context	158
Volume (litres)	5
Block	DB-P
Generic context type	OL
Grain	
Hordeum sp. (C)	11
H. naked (C)	1
H. cf. Naked (C)	1
H. hulled (C)	9
H. cf. Hulled (C)	6
Cereal indeterminate (C)	23
Total grain	51
Chaff	
H. *vulgare* L. (RI)	1
Cereal/monocotyledon (>2 mm.) (CN)	1
Cereal/monocotyledon (>2 mm.) (CB)	1
Total chaff	3
Wild species	
Brassica rapa L. (S)	1
Erica/Calluna spp. (Cap)	4
Poaceae undiff. (medium) (C)	1
Stellaria media (L.) Vill. (S)	2
Cereal/monocotyledon (<2 mm.) (CN)	1
Total wild	9
Total QC	63
QC/litre	12.6
caryopsis/litre	10.2
% grain	81.0
% chaff	4.8
% wild	14.2

Table B3: Macrofossil counts for Dun Bharabhat primary block (**DB-P**)

Context	206
Volume (litres)	5
Block	DB-M
Generic context type	OL
Chaff	0
H. *vulgare* L. (RI)	1
Wild species	1
Brassica rapa L. (S)	39
Chenopodium album L. (S)	1
Polygonum sp. (F)	2
Stellaria media (L.) Vill. (S)	1
Total wild	43
Total QC	44
QC/litre	8.8
caryopsis/litre	0.0
% grain	0.0
% chaff	2.3
% wild	97.7

Table B4: Macrofossil counts for Dun Bharabhat Atlantic roundhouse block (**DB-M**)

Context	169
Volume (litres)	5
Block	DB-S
Generic context type	CON
Grain	
H. *distichon* var. *vulgare* L. (C)	4
H. *vulgare* var. *vulgare* L. asymmetric (C)	7
H. *vulgare* var. *vulgare* L. symmetric (C)	14
H. hulled (C)	77
H. hulled asymmetric (C)	185
H. hulled symmetric (C)	133
Grain total	420
Chaff	
Hordeum sp. (BRI)	34
H. *distichon* var. *vulgare* L. (RI)	28
H. cf. *distichon* var. *vulgare* L. (RI)	28
H. *distichon* var. *vulgare* L. (BRI)	9
H. *distichon* var. *vulgare* L. (SLS)	42
H. *vulgare* var. *vulgare* L. (RI)	150
H. *vulgare* var. *vulgare* L. (BRI)	23
Cereal indeterminate (>2mm) (CF)	1000F+
Cereal/monocotyledon (>2 mm.) (CN)	302
Cereal/monocotyledon (>2 mm.) (CB)	1299
Chaff total	1915
Wild species	
Brassica rapa L. (S)	155
Brassicaceae undiff. (CapB)	2
Calluna vulgaris (L.) Hull. (LF)	18F
Erica tetralix L. (LF)	4F
Erica/Calluna spp. (Cap)	2
Erica/Calluna spp. (LF)	3F
Poaceae undiff. (medium) (C)	3
Poaceae undiff. (medium) (FB/SP)	7
Polygonum cf. *aviculare* L. (F)	8
Polygonum cf. *oxyspermum* Meyer & Bunge ex Ledeb. (F)	2
Polygonum sp. (F)	3
Ranunculus cf. *bulbosus* L. (F)	1
Ranunculus cf. *repens* L. (F)	1
Stellaria media (L.) Vill. (S)	1
Viola sp. (F)	7
Cereal/monocotyledon (<2 mm.) (CB)	169
Cereal/monocotyledon (<2 mm.) (CN)	109
Indeterminate (R)	4
Indeterminate (S/F)	10
Wild total	484
Total QC	2819
QC/litre	563.8
caryopsis/litre	84.0
% grain	14.9
% chaff	67.9
% wild	17.2

Table B5: Macrofossil counts for destruction block at Dun Bharabhat (**DB-S**)

Sample	28	42	47	68	97	104	106	109	110	112	
Context	47	54	67	102	141	128	155	151	152	159	
Block	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	
Volume (litres)	1	14	42	2	28	10	21	14	56	28	
Generic context ype	AS	AS	AS	AS	AS	HM	HM	HM	HM	AS	**Totals**
Grain											
Hordeum											
H. sp. (C)	1								5		6
H. hulled (C)	4		12			3		5	9		33
H. cf. Hulled (C)			7						7		14
H. hulled symmetric (C)	1		1					2		2	6
H. hulled asymmetric (C)	2		1				1		1	3	8
Avena sp. (C)		1									1
Linum usitasitisimum L. (S)			1								1
Cereal indeterminate (C)			3					1	4		8
Total grain	8	1	25	0	0	3	1	8	26	5	77
Chaff											
Cereal/monocotyledon (>2 mm.) (CN)	1										1
Cereal/monocotyledon (>2 mm.) (CB)	1	2	1			1			2	1	8
Total chaff	2	2	1	0	0	1	0	0	2	1	9
Wild species											
Brassica/Sinapis spp. (S)			1								1
Carex spp. (biconvex) (N)								2		1	3
Carex spp. (trigonous) (N)			3					6	3	1	13
Empetrum nigrum L. (F)					3						3
Plantago lanceolata L. (S)								1			1
Poaceae (small) undiff. (C)					2	1		2			5
Poaceae undiff. (medium) (C)			1						2		3
Poaceae undiff. (large) (C)								1			1
Polygonum spp. (N)	1							1	1		3
Rumex acetosella L. (N)							1				1
Rumex crispus L. (N)						1	1				2
Rumex spp. (N)						1		1			2
Stellaria media (L.) Villars (S)					1		1				2
Vaccinium myrtillus L. (S)			1						1		2
cf. *Vicia/Lathyrus* spp. (S)						1					1
Cereal/monocotyledon (<2 mm.) (CN)					1				2		3
Cereal/monocotyledon (<2 mm.) (CB)		3	3		1	2	2	5	7	1	24
Indeterminate (>2 mm.) (R)	1	2			3			2			8
Indeterminate (<2 mm.) (R)		2	1	12	24	2		5	2	1	49
Indeterminate seed/fruit (S/F)			10		2	2	8	5	15		42
Total wild	2	7	20	12	37	10	13	31	33	4	169
Total QC	12	10	46	12	37	14	14	39	61	10	255
QC/litre	12.0	0.7	1.1	6.0	1.3	1.4	0.7	2.8	1.1	0.4	
caryopsis/litre	8.0	0.1	0.6	0.0	0.0	0.3	0.0	0.6	0.5	0.2	
% grain	66.7	10.0	54.3	0.0	0.0	21.4	7.1	20.5	42.6	50.0	
% chaff	16.7	20.0	2.2	0.0	0.0	7.1	0.0	0.0	3.3	10.0	
% wild	16.7	70.0	43.5	100.0	100.0	71.4	92.9	79.5	54.1	40.0	

Table B6: Macrofossil counts for An Dunan funerary structure (**AD-IA**)

Sample	245	253	262	272	307	308	311	311 A&B	318	350	360	365	
Context	372	373	390	397	437	436	443	443	450	497	514	518	
Block	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	
Generic context type	AS	FL	HM	AS	HM	AS	HM	HM	FL	FL	FL	FL	
Volume (litres)	14	14	14	14	14	14	7	7	14	14	14	14	**Totals**
Grain													
Hordeum sp. (C)		2		1			1				1		5
H. hulled (C)			4	4		4				1	2		15
H. cf. Hulled (C)												1	1
H. hulled symmetric (C)		1		1			2						4
H. hulled asymmetric (C)		1		3					1	1			6
Avena sp. (C)	1	7		10			1						19
Cereal indeterminate (C)		1	1	2		1					1		6
Grain total	1	12	5	21	0	5	4	0	1	2	4	1	56
Chaff													
Cereal/monocotyledon (>2 mm.) (CB)	1	2		6		2		4		2		1	18
Chaff total	1	2	0	6	0	2	0	4	0	2	0	1	18
Wild species													
Arctostaphylos uva-ursi (L.) Sprengel (F)	1					1							2
Brassica cf. *rapa* L. (S)										1			1
Brassica/Sinapis spp. (S)		2	2			1				2		2	9
Calluna vulgaris (L.) Hull. (Cap)			1	4									5
Calluna vulgaris (L.) Hull. (LF)	1F			38F									0
Carex spp. (biconvex) (N)		1	3	2		2			2				10
Carex spp. (trigonous) (N)		2		1	2	3			3				11
Danthonia decumbens L. (C)	1	1	2	1							1		6
Empetrum nigrum L. (F)			1			1							2
Erica/Calluna spp. (Cap)		1		2		1							4
Plantago lanceolata L. (S)			1				1					1	3
Poaceae (small) undiff. (C)				2	1								3
Poaceae (medium) undiff. (C)				6									6
Poaceae undiff. (large) (C)				2			1						3
Polygonum aviculare L. (N)				1									1
Rumex acetosella L. (N)					1				1				2
Rumex crispus L. (N)	9	2			1	1				1			14
Rumex spp. (N)							1			1			2
Spergula arvensis L. (S)						1							1
Stellaria media (L.) Villars (S)		1	1		1	2			5				10
Vaccinium myrtillus L. (S)						1							1
Vaccinium vitis-idaea L. (S)				1									1
Viola sp. (S)				1									1
Cereal/monocotyledon (<2 mm.) (CN)				14		3			1		1		19
Cereal/monocotyledon (<2 mm.) (CB)	6	7	4	8	3	11	2	3		1	4	4	53
Indeterminate (>2 mm.) (R)	12	18	1	92	3	13		1	2	4	1	9	156
Indeterminate (<2 mm.) (R)	8	20	4	177	3	41	2	3	4	2	3	4	271
Indeterminate seed/fruit (S/F)			3	6	1	4	1		4	1	2	1	23
Indeterminate (trigonous) (S/F)			2										2
Indeterminate pericarp fragment (PF)			1		1								2
Total wild	37	55	26	320	17	86	8	7	22	13	12	21	624
Total QC	39	69	31	347	17	93	12	11	23	17	16	23	
QC/litre	2.8	4.9	2.2	24.8	1.2	6.6	1.7	1.6	1.6	1.2	1.1	1.6	
caryopsis/litre	0.1	0.9	0.4	1.5	0.0	0.4	0.6	0.0	0.1	0.1	0.3	0.1	
% grain	2.6	17.4	16.1	6.1	0.0	5.4	33.3	0.0	4.3	11.8	25.0	4.3	
% chaff	2.6	2.9	0.0	1.7	0.0	2.2	0.0	36.4	0.0	11.8	0.0	4.3	
% wild	94.9	79.7	83.9	92.2	100.0	92.5	66.7	63.6	95.7	76.5	75.0	91.3	

Table B7: Macrofossil counts for Guinnerso Mid Iron Age block (**GUN-IA**)

Sample number	3	70	15	
Context number	32	201	86	
Block	CN-W	CN-W	CN-W	
Generic context type	AS	FL	OL	
Sample volume (litres)	6.0	1.0	5.0	Total
Grain				
Hordeum sp. (C)	5	2	4	11
H. cf. Hulled (C)	7		8	15
H. hulled (C)	18	4	8	30
H. hulled symmetric (C)	6	2	2	10
H. hulled asymmetric (C)	18		5	23
Cereal indeterminate (C)	6	3	1	10
Total grain	60	11	28	99
Chaff				
H. *vulgare* L. (RI)		1		1
Cereal/monocotyledon (>2 mm.) (CB)		1	4	5
Total chaff	0	2	4	6
Wild species				
Cereal/monocotyledon (<2 mm.) (CB)	2			2
Indeterminate (>2 mm.) (R)	1			1
Total wild	3	0	0	3
Total QC	63	13	32	
QC/litre	10.50	13.00	6.40	
caryopsis/litre	10.00	11.00	5.60	
% grain	95.2	84.6	87.5	
% chaff	0.0	15.4	12.5	
% wild	4.8	0.0	0.0	

Table B8: Macrofossil counts for Cnip Wheelhouse block (**CN-W**)

Sample number	62
Context number	182
Block	CN-C
Generic context type	FL
Sample volume (litres)	1.5
Grain	
H. cf. hulled (C)	6
H. hulled (C)	4
H. hulled asymmetric (C)	1
Total grain	11
Chaff	
Cereal/monocotyledon (>2 mm.) (CB)	1
Total chaff	1
Wild species	
Indeterminate (S/F)	1
Total wild	1
Total QC	13
QC/litre	8.67
caryopsis/litre	7.3
% grain	84.6
% chaff	7.7
% wild	7.7

Table B9: Macrofossil counts for Cnip Cellular block (**CN-C**)

Sample number	1	13	16	61	
Context number	20	83	83	166	
Block	CN-R	CN-R	CN-R	CN-R	
Generic context type	FL	FL	FL	NFF	
Sample volume (litres)	3.5	2.0	7.0	2.0	Total
Grain					
Hordeum sp. (C)		2	1	2	5
H. cf. Hulled (C)				3	3
H. hulled (C)			2	7	9
H. hulled symmetric (C)			1	1	2
H. hulled asymmetric (C)		2	3	2	7
Cereal indeterminate (C)			2	3	5
Total grain	0	4	9	18	31
Chaff					
H. *vulgare* L. (RI)				1	1
Cereal/monocotyledon (>2 mm.) (CN)			1		1
Cereal/monocotyledon (>2 mm.) (CB)	1	2	5		8
Total chaff	1	2	6	1	10
Wild species					
Brassica/Sinapis spp. (S)				4	4
Brassicaceae undiff. (CapB)	1				1
Calluna vulgaris (L.) Hull. (LF)	1F				0
Calluna vulgaris (L.) Hull. (Cap)	1				1
Carex spp. (biconvex) (N)	4	3			7
Carex spp. (trigonous) (N)	6	2			8
Danthonia decumbens L. (C)		1			1
Hypericum pulchrum L. (S)		4			4
Poaceae undiff. (medium) (C)		2	1		3
Polygonum spp. (N)			1		1
Rumex cf. *crispus* L. (N)	5				5
Viola sp. (S)	1				1
Cereal/monocotyledon (<2 mm.) (CN)	1				1
Cereal/monocotyledon (<2 mm.) (CB)	6	8	3	1	18
Indeterminate (>2 mm.) (R)	2				2
Indeterminate (<2 mm.) (R)		1			1
Indeterminate (S/F)	2	5			7
Total wild	29	26	5	5	65
Total QC	30	32	20	24	
QC/litre	8.6	16.0	2.9	12.0	
caryopsis/litre	0.0	2.0	1.3	9.0	
% grain	0.0	12.5	45.0	75.0	
% chaff	3.3	6.3	30.0	4.2	
% wild	96.7	81.3	25.0	20.8	

Table B10: Macrofossil counts for Cnip Rectilinear block (**CN-R**)

Sample	344
Context	559
Block	LB-R
Generic context type	M
Volume (litres)	161
Grain	
Hordeum sp. (C)	5
H. hulled (C)	26
H. cf. hulled (C)	12
H. hulled symmetric (C)	5
H. hulled asymmetric (C)	7
Avena sp. (C)	1
Linum usitasitissimum L. (S)	2
Cereal indeterminate (C)	4
Total grain	62
Chaff	
Hordeum sp. (RI)	2
H. *vulgare* L. (RI)	13
H. *distichon* L. (RI)	1
Cereal/monocotyledon (>2 mm.) (CN)	2
Cereal/monocotyledon (>2 mm.) (CB)	11
Wild species	29
Arctostaphylos uva-ursi (L.) Sprengel (F)	1
Brassica cf. *rapa* L. (S)	36
Brassica/Sinapis spp. *(S)*	3
Calluna vulgaris (L.) Hull. (Cap)	2
Calluna vulgaris (L.) Hull. (LF)	16F
Carex spp. (biconvex) (N)	6
Carex spp. (trigonous) (N)	11
Chenopodium/Atriplex spp. (S)	1
Erica/Calluna spp. (Cap)	7
Fumaria officanalis L. (F)	1
Galeopsis tetrahit L. (N)	1
Juniperis communis L. (PF)	1
Montia fontana L. (S)	1
Plantago lanceolata L. (S)	4
Poaceae (small) undiff. (C)	3
Poaceae undiff. (large) (C)	1
Poaceae undiff. (medium) (C)	3
Polygonum spp. (N)	3
Potentilla erecta (L.) Raeusch (S)	1
Rumex acetosa L. (N)	1
Rumex crispus L. (N)	7
Rumex spp. (N)	2
Stellaria media (L.) Villars (S)	16
Trifolium sp. (S)	1
Viola sp. (S)	1
Cereal/monocotyledon (<2 mm.) (CN)	1
Cereal/monocotyledon (<2 mm.) (CB)	4
Indeterminate (>2 mm.) (R)	2
Indeterminate (<2 mm.) (R)	5
Indeterminate (S/F)	18
Indeterminate (trigonous) (S/F)	3
Total wild	147
Total QC	238
QC/litre	1.5
caryopsis/litre	0.4
% grain	26.1
% chaff	12.2
% wild	61.8

Table B11: Macrofossil counts for Loch na Beirgh Roundhouse block **(LB-R)**

Sample	89/3	204	94/5	171	206	207	94/8	230	257	236	361	240	295	322
Context	246	469	426	438a	470	471	438b	462	522	507	577	509	540	552
Block	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C
Generic context type	M	FL	FL	HM	HM	HM	HM	FL	NFF	HM	HM	M	M	HM
Volume (litres)	5	10	14	14	4.5	10	14	56	14	56	28	11	11	28
Grain														
Hordeum sp. (C)	14	3		140	1	2	18	2	2	3	1	1	3	
H. naked symmetric (C)														
H. naked asymmetric (C)														
H. hulled (C)	32	6	4	500	1	1	35	5	9	11	5	9	8	17
H. cf. Hulled (C)	6	4	2	144			17	4		2	1		3	2
H. hulled symmetric (C)	9			188		1	8	6	2	8	3	2	4	4
H. hulled asymmetric (C)	7		2	328		2	20	9	3	6	4	1	2	9
Triticum sp. (C)				4										
Avena sp. (C)														
Linum usitasitissimum L. (S)													4	
Cereal indeterminate (C)	7	2	2	152			6		2	2				
Total grain	75	15	10	1456	2	6	104	26	18	32	14	13	24	32
Chaff														
Hordeum sp. (AF)											1			
Hordeum sp. (BRI)				6										
Hordeum sp. (RI)				24			1			1				
H. *vulgare* L. (BRI)				5										
H. *vulgare* L. (RI)		1	1	120			3		1					
H. *distichon* L. (RI)				10				1						
H. *distichon* L. (SLS)				1										
A. *sativa* L. (FB)														
Cereal/monocotyledon (>2 mm.) (CN)		1	1	10				2		1		2		1
Cereal/monocotyledon (>2 mm.) (CB)	2	6		76	4		67	8	3	45	8	5	1	19
Total chaff	2	8	2	252	4	0	71	11	4	47	9	7	1	20

Table B12a: Macrofossil counts for Loch an Beirgh Cellular block (**LB-C**); grain and chaff

Sample	229	366	379	305	241	325	
Context	503	580	578	541	515	555	
Block	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	
Generic context type	HM	HM	HM	FL	FL	NFF	
Volume (litres)	28	14	28	56	28	49	**Totals**
Grain							
Hordeum sp. (C)	97	21	1	12		2	323
H. naked symmetric (C)				1			1
H. naked asymmetric (C)		1					1
H. hulled (C)	162	99	9	20	6	22	961
H. cf. Hulled (C)	69	17	1	6		9	287
H. hulled symmetric (C)	63	25	2	12	4	14	355
H. hulled asymmetric (C)	128	54	1	23	1	11	611
Triticum sp. (C)							4
Avena sp. (C)	1	1				1	3
Linum usitasitissimum L. (S)			1				5
Cereal indeterminate (C)	58	7	2	3			243
Total grain	578	225	17	77	11	59	2794
Chaff							
Hordeum sp. (AF)							1
Hordeum sp. (BRI)	3						9
Hordeum sp. (RI)	10						36
H. *vulgare* L. (BRI)	9						14
H. *vulgare* L. (RI)	189	11	1	17		2	346
H. *distichon* L. (RI)	4	1		1		1	18
H. *distichon* L. (SLS)							1
A. *sativa* L. (FB)				2			2
Cereal/monocotyledon (>2 mm.) (CN)	4		1	4	3	2	32
Cereal/monocotyledon (>2 mm.) (CB)	49	16	23	3	2	46	383
Total chaff	268	28	25	27	5	51	842

Table B12b: Macrofossil counts for Loch an Beirgh Cellular block (**LB-C**); grain and chaff continued

Sample	89/3	204	94/5	171	206	207	94/8	230	257	236	361
Context	246	469	426	438a	470	471	438b	462	522	507	577
Block	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C
Generic context type	M	FL	FL	HM	HM	HM	HM	FL	NFF	HM	HM
Volume (litres)	5	10	14	14	4.5	10	14	56	14	56	28
Wild species											
Arctostaphylos uva-ursi (L.) Sprengel (F)										5	
Brassica cf. *rapa* L. (S)			4	2				18		1	
Brassica/Sinapis spp. (S)					1					1	
Brassicaceae undiff. (S)			1								
Calluna vulgaris (L.) Hull. (Cap)				9				6		1	
Calluna vulgaris (L.) Hull. (LF)				5F				4F		3F	
Carex spp. (biconvex) (N)				2	1					2	1
Carex spp. (trigonous) (N)				6	3	1	9	3	2	14	
Chenopodium album L. (S)											
Chenopodium/Atriplex spp. (S)					1			1			
Corylus avellana L. (NF)								1F			
Cyperaceae undiff. (S)				1							
Danthonia decumbens L. (C)	1									1	
Eleocharis palustris L. (N)										1	
Empetrum nigrum L. (F)								1		2	
Erica tetralix L. (LF)	1F										
Erica/Calluna spp. (Cap)			1	3	52		6	1		3	
Fumaria officanalis L. (F)						1		1			
Persicaria lapathifolia (L.) Gray (N)											
Plantago lanceolata L. (S)										1	
Poaceae (small) undiff. (C)					1						
Poaceae undiff. (large) (C)											
Poaceae undiff. (medium) (C)					1						
Polygonum aviculare L. (N)		1		1			1				
Polygonum spp. (N)		1					1				
Potentilla sp. (S)				2							
Ranunculus repens L. (A)										1	
Ranunculus spp. (A)											
Rumex acetosella L. (N)										1	
Rumex crispus L. (N)						1	3		1	9	
Rumex spp. (N)				6				1			
Sinapis arvensis L. (S)											
Sorbus sp. (S)								1			
Stellaria media (L.) Villars (S)		1									
Vaccinium myrtillus L. (S)					1						
Viola sp. (S)							1				
Cereal/monocotyledon (<2 mm.) (CN)		1		12	1		2				1
Cereal/monocotyledon (<2 mm.) (CB)	1	6	1	140			36			20	
Indeterminate (>2 mm.) (R)	2			4	2	1	11			1	
Indeterminate (<2 mm.) (R)				13			10	1		3	
Seaweed (LF)											
Indeterminate seed/fruit (S/F)			1	11	1		3	2	2	5	1
Indeterminate pericarp fragment PF)											
Total wild	4	10	8	212	65	4	83	36	5	72	3
Cenococcum (carbonised)							1	2		3	
Total QC	81	33	20	1920	71	10	258	73	27	151	26
QC/litre	16.2	3.3	1.4	137.1	15.8	1.0	18.4	1.3	1.9	2.7	0.9
caryopsis/litre	15.0	1.5	0.7	104.0	0.4	0.6	7.4	0.5	1.3	0.6	0.5
% grain	92.6	45.5	50.0	75.8	2.8	60.0	40.3	35.6	66.7	21.2	53.8
% chaff	2.5	24.2	10.0	13.1	5.6	0.0	27.5	15.1	14.8	31.1	34.6
% wild	4.9	30.3	40.0	11.0	91.5	40.0	32.2	49.3	18.5	47.7	11.5

Table B12c: Macrofossil counts for Loch an Beirgh Cellular block (**LB-C**); wild components

Sample	240	295	322	229	366	379	305	241	325	
Context	509	540	552	503	580	578	541	515	555	
Block	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	
Generic context type	M	M	HM	HM	HM	HM	FL	FL	NFF	
Volume (litres)	11	11	28	28	14	28	56	28	49	**Totals**
Wild species										
Arctostaphylos uva-ursi (L.) Sprengel (F)		1								6
Brassica cf. *rapa* L. (S)	2	1		2	1		21	7	8	67
Brassica/Sinapis spp. (S)	3	4		1	2	1	2		6	21
Brassicaceae undiff. (S)										1
Calluna vulgaris (L.) Hull. (Cap)				1	1		9	1		28
Calluna vulgaris (L.) Hull. (LF)				9F		20F	13F		3F	0
Carex spp. (biconvex) (N)	1		1		2	1	1			12
Carex spp. (trigonous) (N)			3	7	4		1		2	55
Chenopodium album L. (S)							3			3
Chenopodium/Atriplex spp. (S)				7						9
Corylus avellana L. (NF)	1F									0
Cyperaceae undiff. (S)										1
Danthonia decumbens L. (C)										2
Eleocharis palustris L. (N)				1	1					3
Empetrum nigrum L. (F)										3
Erica tetralix L. (LF)				1F						0
Erica/Calluna spp. (Cap)				4		3	8		10	91
Fumaria officanalis L. (F)				1	3					6
Persicaria lapathifolia (L.) Gray (N)							1			1
Plantago lanceolata L. (S)		1		5		3				10
Poaceae (small) undiff. (C)						3			1	5
Poaceae undiff. (large) (C)		5	1							6
Poaceae undiff. (medium) (C)				1		1				3
Polygonum aviculare L. (N)						1				4
Polygonum spp. (N)		1			1					4
Potentilla sp. (S)										2
Ranunculus repens L. (A)										1
Ranunculus spp. (A)						1			1	2
Rumex acetosella L. (N)										1
Rumex crispus L. (N)				2		3	1		2	22
Rumex spp. (N)			1			1	1		2	12
Sinapis arvensis L. (S)					1					1
Sorbus sp. (S)										1
Stellaria media (L.) Villars (S)						1	2			4
Vaccinium myrtillus L. (S)										1
Viola sp. (S)										1
Cereal/monocotyledon (<2 mm.) (CN)		1							2	20
Cereal/monocotyledon (<2 mm.) (CB)		1	8	11	7	35	3		31	300
Indeterminate (>2 mm.) (R)	1		4	2	2	3	1		4	38
Indeterminate (<2 mm.) (R)		1				4			1	33
Seaweed (LF)									1F	0
Indeterminate seed/fruit (S/F)				6		4	2	2	2	42
Indeterminate pericarp fragment PF)				1						1
Total wild	7	16	18	52	25	65	56	10	72	823
Cenococcum (carbonised)			1	3		2	4		4	
Total QC	27	41	70	898	278	107	160	26	182	
QC/litre	2.5	3.7	2.5	32.1	19.9	3.8	2.9	0.9	3.7	
caryopsis/litre	1.2	2.2	1.1	20.6	16.1	0.6	1.4	0.4	1.2	
% grain	48.1	58.5	45.7	64.4	80.9	15.9	48.1	42.3	32.4	
% chaff	25.9	2.4	28.6	29.8	10.1	23.4	16.9	19.2	28.0	
% wild	25.9	39.0	25.7	5.8	9.0	60.7	35.0	38.5	39.6	

Table B12d: Macrofossil counts for Loch an Beirgh Cellular block (**LB-C**); wild components continued

Sample	6	59	
Context	301	400	
Block	GAL-LIA	GAL-LIA	
Generic context type	FL	AS	
Volume (litres)	4	2	**Total**
Grain			
Hordeum sp. (C)	2	7	9
H. naked symmetric (C)		4	4
H. hulled (C)	1	3	4
H. hulled asymmetric (C)		7	7
Cereal indeterminate (C)		9	9
Grain total	3	30	33
Chaff			
Cereal/monocotyledon (>2 mm.) (CB)	3		3
Chaff total	3	0	3
Wild species			
Polygonum spp. (N)		1	1
Cereal/monocotyledon (<2 mm.) (CN)	2		2
Cereal/monocotyledon (<2 mm.) (CB)	1		1
Indeterminate (>2 mm.) (R)	2		2
Indeterminate (<2 mm.) (R)	11		11
Indeterminate seed/fruit (S/F)	1		1
Total wild	17	1	18
Total QC	23	31	
QC/litre	5.8	15.5	
caryopsis/litre	0.8	15.0	
% grain	13.0	96.8	
% chaff	13.0	0.0	
% wild	73.9	3.2	

Table B13: Macrofossil counts for Galson Late Iron Age block **(GAL-LIA)**

sample	204
context	632
context type	NFF
block	BO-E
Volume (litres)	35
Grain	
Hordeum sp. (C)	4
H. hulled (C)	2
H. cf. Hulled (C)	1
Grain total	7
Wild species	
Rumex crispus L. (N)	1
Rumex spp. (N)	1
Cereal/monocotyledon (<2 mm.) (CB)	1
Wild total	3
Total QC	10
QC/litre	0.3
caryopsis/litre	0.2
% grain	70.0
% chaff	0.0
% wild	30.0

Table B14: Macrofossil counts for Bostadh Early block **(BO-E)**

sample	154	292	293	189	283	286	289	290	291	155	122	143
context	234	867	868	623	624	862	354	863	866	261	214	250
context type	FL	HM	NFF	M	NFF	HM	FL	HM	HM	FL	M	FL
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA
Volume (litres)	14	10	10	21	14	24	14	7	10	112	14	98
Grain												
Hordeum sp. (C)	1	6	11	6	164	11	20	128	89	144	4	7
H. naked (C)				1								
H. cf. Naked (C)				1						2		
H. naked symmetric (C)				1								
H. naked asymmetric (C)												
H. hulled (C)	2	7	6		38	14	20	138	56	176	25	
H. cf. Hulled (C)		4	2		82	3	7	61	27	12	7	1
H. hulled symmetric (C)	1	4	5		8	11		22	15	244	3	2
H. hulled asymmetric (C)		7	7	1	18	9	5	45	31	440	4	
Triticum sp. (C)					2							1
Avena sp. (C)			1		2	1			1	1		
A. *sativa* L. (C)												
Secale cereale L. (C)												
Linum sp. (S)		1		1		7		2		200		
Cereal indeterminate (C)	2	1	4		304	7	48	110	56	80	2	4
Total grain	6	30	36	11	618	63	100	506	275	1299	45	15
Chaff												
H. *vulgare* L. (RI)										5		
H. *vulgare* L. (BRI)										1		
H. cf. *vulgare* L. (RI)										1		
H. *distichon* L. (RI)										2		
A. *sativa* L. (FB)										1		
Cereal/monocotyledon (>2 mm.) (CN)										2		
Cereal/monocotyledon (>2 mm.) (CB)			1	1		1				26	2	2
Total chaff	0	0	1	1	0	1	0	0	0	38	2	2

Table B15a: Macrofossil counts for Bostadh 'figure-of-eight' block (**BO-LIA**); grain and chaff

sample	156	158	57	101	133	130	128	134	136	177	308	309
context	264	263	123	200	249	248	164	148	148	319	879	884
context type	FL	FL	M	OL	AS	M	FL	FL	FL	NFF	NFF	NFF
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA
Volume (litres)	28	11	84	14	14	21	14	28	84	28	14	84
Grain												
Hordeum sp. (C)	2	9	22	13	30	3	2	2	42	6		8
H. naked (C)												
H. cf. Naked (C)			9		7					1		
H. naked symmetric (C)												
H. naked asymmetric (C)												
H. hulled (C)	3	4	52	3	224	10	25	6	37	2	1	7
H. cf. Hulled (C)		4	6	3	76	3	2		17		1	6
H. hulled symmetric (C)	3	1	15	2	98	3	6		32		3	2
H. hulled asymmetric (C)	3	2	26	2	152	5	11		23			2
Triticum sp. (C)					1		1					
Avena sp. (C)			3		16	4	4		5	1		
A. *sativa* L. (C)												
Secale cereale L. (C)		1										
Linum sp. (S)							3	1		1	1	1
Cereal indeterminate (C)	1	13	6		41				26	12	6	7
Total grain	12	34	139	23	645	28	54	9	182	23	12	33
Chaff												
H. *vulgare* L. (RI)						1						
H. *vulgare* L. (BRI)												
H. cf. *vulgare* L. (RI)												
H. *distichon* L. (RI)												
A. *sativa* L. (FB)												
Cereal/monocotyledon (>2 mm.) (CN)			2		2				2			3
Cereal/monocotyledon (>2 mm.) (CB)	5	13	66	1	57	17		3	20		3	13
Total chaff	5	13	68	1	59	18	0	3	22	0	3	16

Table B15b: Macrofossil counts for Bostadh 'figure-of-eight' block (**BO-LIA**); grain and chaff continued

sample	313	317	323	324	138	144	150	166	170.1	170.2	246	287
context	885/2	885/3	885/6	885/7	226	227	230	317	318.a	318.b	659	362
context type	NFF	NFF	NFF	NFF	OL	OL	OL	NFF	HM	HM	NFF	HM
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA
Volume (litres)	14	14	14	14	28	28	14	14	14	14	14	92
Grain												
Hordeum sp. (C)	6	8	124	19		1	1	6	424	3	2	51
H. naked (C)			1									
H. cf. Naked (C)			1					1				1
H. naked symmetric (C)												
H. naked asymmetric (C)							1					
H. hulled (C)	10	11	133	36		1	2		296	2	2	67
H. cf. Hulled (C)	3	3	47	6				3	140	1	1	34
H. hulled symmetric (C)	3	11	37	10		1			176		2	32
H. hulled asymmetric (C)	2	11	72	20		1	2		364	1	1	75
Triticum sp. (C)			4	1					20			
Avena sp. (C)					1	1			8			
A. *sativa* L. (C)												
Secale cereale L. (C)												
Linum sp. (S)					1							34
Cereal indeterminate (C)	15	6	123	31			4		112	13		36
Total grain	39	50	542	123	2	5	10	10	1540	20	8	330
Chaff												
H. *vulgare* L. (RI)			1									
H. *vulgare* L. (BRI)												
H. cf. *vulgare* L. (RI)			1									
H. *distichon* L. (RI)												
A. *sativa* L. (FB)												
Cereal/monocotyledon (>2 mm.) (CN)					1				1			
Cereal/monocotyledon (>2 mm.) (CB)	5				6		1					19
Total chaff	5	0	2	0	7	0	1	0	1	0	0	19

Table B15c: Macrofossil counts for Bostadh 'figure-of-eight' block (**BO-LIA**); grain and chaff continued

sample	318	319	320	328	331	124.1	151	?	176	91	?	253
context	887	891	889	890	888	173	221	315	358	174	314	498
context type	NFF	NFF	NFF	NFF	HM	FL	FL	FL	NFF	M	M	OL
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA
Volume (litres)	7	7	14	14	28	238	336	14	8	56	14	14
Grain												
Hordeum sp. (C)	3	1	13	5	8	5	24	67		4	3	
H. naked (C)							2					
H. cf. Naked (C)												
H. naked symmetric (C)												
H. naked asymmetric (C)												
H. hulled (C)	4	6	5	10	27	22	7	62		15	4	
H. cf. Hulled (C)	4		1	5	5	6	7	28	6	4	2	
H. hulled symmetric (C)	2	1	3	10	6	8	5	31		2	1	
H. hulled asymmetric (C)	2	3	1	12	11	11	11	54		5	2	
Triticum sp. (C)			2			1	1	1				
Avena sp. (C)	1		1		1	8	5	2		3		
A. *sativa* L. (C)												
Secale cereale L. (C)												
Linum sp. (S)		2	4		2	1	2	2		1		
Cereal indeterminate (C)	4	2	7	9	8	5	22	28	11		2	
Total grain	20	15	37	51	68	67	86	275	17	34	14	0
Chaff												
H. *vulgare* L. (RI)				14								
H. *vulgare* L. (BRI)									1			
H. cf. *vulgare* L. (RI)								1				
H. *distichon* L. (RI)												
A. *sativa* L. (FB)												
Cereal/monocotyledon (>2 mm.) (CN)										3	1	
Cereal/monocotyledon (>2 mm.) (CB)		2	7	14	82	9	7	11		23	4	6
Total chaff	0	2	7	28	82	9	7	12	1	26	5	6

Table B15d: Macrofossil counts for Bostadh 'figure-of-eight' block (**BO-LIA**); grain and chaff continued

sample	232	187	198	207	211	226	248	249	250	251	261	284
context	481	439	464	445	287	479	471	466	493	471	714	714
context type	M	OL	NFF	NFF	M	AS	OL	OL	NFF	OL	AS	AS
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA
Volume (litres)	28	28	21	14	31	3	42	42	14	14	9	21
Grain												
Hordeum sp. (C)	5	3	2	2	8		8	15	5	3	35	106
H. naked (C)			1					1			1	
H. cf. Naked (C)								1	1			
H. naked symmetric (C)												
H. naked asymmetric (C)			1									1
H. hulled (C)	4	1	2	1	11			12	1	4	16	81
H. cf. Hulled (C)	2	2			3		2	11	1	2	7	25
H. hulled symmetric (C)			7		2		2	3	1	1	8	32
H. hulled asymmetric (C)	3	2	6		1		1	5		4	12	69
Triticum sp. (C)												
Avena sp. (C)			1			8					1	7
A. *sativa* L. (C)						1						
Secale cereale L. (C)												
Linum sp. (S)	8							3			1	1
Cereal indeterminate (C)	6		1		7		5	15	5	4	55	70
Total grain	28	8	21	3	32	9	18	66	14	18	136	392
Chaff												
H. *vulgare* L. (RI)			1		2			1	1			
H. *vulgare* L. (BRI)												
H. cf. *vulgare* L. (RI)												
H. *distichon* L. (RI)												
A. *sativa* L. (FB)						1						
Cereal/monocotyledon (>2 mm.) (CN)												
Cereal/monocotyledon (>2 mm.) (CB)	6	1	4	3	4	1	3	8				10
Total chaff	6	1	5	3	6	2	3	9	1	0	0	10

Table B15e: Macrofossil counts for Bostadh 'figure-of-eight' block (**BO-LIA**); grain and chaff continued

sample	288	297	298	299	300	325	326	327	330	137	238	221
context	742	717	744	748	743	738	753	751	749	285	531	518
context type	HM	M	HM	HM	HM	HM	NFF	NFF	HM	M	OL	OL
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA
Volume (litres)	14	28	14	14	21	28	28	56	14	65	28	14
Grain												
Hordeum sp. (C)	3	2	313	456	372	55	129	86	88	10	4	3
H. naked (C)			4		1							
H. cf. Naked (C)			6	4	1					1		
H. naked symmetric (C)			2	2			1					
H. naked asymmetric (C)			4	2	1	1						
H. hulled (C)	7	7	139	120	148	35	175	57	12	9		
H. cf. Hulled (C)			69	112	100	22	70	29	20	3	1	3
H. hulled symmetric (C)			52	44	108	16	73	27	6	5		1
H. hulled asymmetric (C)			112	52	88	31	137	56	12	5		1
Triticum sp. (C)					8							
Avena sp. (C)			31	11	20	1	2	2				
A. *sativa* L. (C)												
Secale cereale L. (C)												
Linum sp. (S)			11	3	1	7	912	7				
Cereal indeterminate (C)	6	3	371	330	296	64	112	58	76	7	2	2
Total grain	16	12	1114	1136	1144	232	1611	322	214	40	7	10
Chaff												
H. *vulgare* L. (RI)			1				6				1	
H. *vulgare* L. (BRI)												
H. cf. *vulgare* L. (RI)												
H. *distichon* L. (RI)												
A. *sativa* L. (FB)												
Cereal/monocotyledon (>2 mm.) (CN)								3		3		
Cereal/monocotyledon (>2 mm.) (CB)		2			2	2	22	36		22		
Total chaff	0	2	1	0	2	2	28	39	0	25	1	0

Table B15f: Macrofossil counts for Bostadh 'figure-of-eight' block (**BO-LIA**); grain and chaff continued

sample	276	277	279	281	282	200	280	247	
context	575	574	583	570	584	513	581	537	
context type	NFF	HM	NFF	NFF	NFF	AS	OL	OL	
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	
Volume (litres)	14	28	14	14	14	35	7	35	
Grain									**Total**
Hordeum sp. (C)	16	42		1	4	3	19	5	3311
H. naked (C)		1							13
H. cf. Naked (C)									37
H. naked symmetric (C)									6
H. naked asymmetric (C)									11
H. hulled (C)	24	57	10	6	17	2	18	1	2555
H. cf. Hulled (C)	6	27	4		3	1	9	3	1167
H. hulled symmetric (C)	4	14	2		6		4		1239
H. hulled asymmetric (C)	10	22	1	1	8		4		2097
Triticum sp. (C)	1								44
Avena sp. (C)	1	2			1				158
A. *sativa* L. (C)									1
Secale cereale L. (C)									1
Linum sp. (S)		1							1222
Cereal indeterminate (C)	4	51	5	3	6	3	19	6	2760
Total grain	66	217	22	11	45	9	73	15	14622
Chaff									
H. *vulgare* L. (RI)		2							36
H. *vulgare* L. (BRI)		1							3
H. cf. *vulgare* L. (RI)									3
H. *distichon* L. (RI)									2
A. *sativa* L. (FB)									2
Cereal/monocotyledon (>2 mm.) (CN)									23
Cereal/monocotyledon (>2 mm.) (CB)	9	29			1	4	3		599
Total chaff	9	32	0	0	1	4	3	0	668

Table B15g: Macrofossil counts for Bostadh 'figure-of-eight' block **(BO-LIA)**; grain and chaff continued

sample	154	292	293	189	283	286	289	290	291	155	122	143
context	234	867	868	623	624	862	354	863	866	261	214	250
context type	FL	HM	NFF	M	NFF	HM	FL	HM	HM	FL	M	FL
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA
Volume (litres)	14	10	10	21	14	24	14	7	10	112	14	98
Wild species												
Ajuga reptans L. (S)												
Arctostaphylos uva-ursi (L.) Sprengel (F)												
Brassica cf. *rapa* L. (S)	1	2	1							1		
Brassica/Sinapis spp. (S)	1		2							2	1	
Calluna vulgaris (L.) Hull. (Cap)												
Calluna vulgaris (L.) Hull. (LF)						1F				5F		
Carex spp. (biconvex) (N)										10		
Carex spp. (trigonous) (N)			1						1	10		
Chenopodium album L. (S)						1				1	1	
Chenopodium/Atriplex spp. (S)												
Corylus avellana L. (NF)												
Danthonia decumbens L. (C)												
Eleocharis palustris L. (N)					2	1				8		
Empetrum nigrum L. (F)											2	
Erica tetralix L. (LF)												
Erica/Calluna spp. (C)												
Fallopia convolvulus L. A. Love (N)												
Fumaria officanalis L. (F)											1	
Galeopsis tetrahit L. (N)												
Galium aparine L. (N)												
Montia fontana L. (S)										3		
Persicaria lapathifolia (L.) Gray (N)									1	3		
Persicaria maculosa Gray (N)												
Plantago lanceolata L. (S)										6		
Poa cf. *annua* L. (C)												
Poaceae (small) undiff. (C)					1					5		
Poaceae undiff. (large) (C)						4				5	1	
Poaceae undiff. (medium) (C)		2				3		1		100	1	
Polygonum aviculare L. (N)										1		
Polygonum spp. (N)						3	1			6		
Pteridium aquilinium (L.) Kuhn (LF)						1F				1F		
Ranunculus bulbosus L. (A)												
Ranunculus repens L. (A)												
Ranunculus spp. (A)												
Raphanus raphanistrum L. (F)												
Rumex acetosa L. (N)										2		
Rumex acetosella L. (N)					2					8		
Rumex crispus L. (N)	1			1	3		2	1	1	14		
Rumex spp. (N)					1					4		
Spergula arvensis L. (S)						3				94		
Stachys cf. *palustris* L. (F)												
Stellaria media (L.) Villars (S)										7		
Trifolium repens L. (S)												
Urtica dioica L. (F)						3				24		
Viola sp. (S)										6		
Cereal/monocotyledon (<2 mm.) (CN)										25		
Cereal/monocotyledon (<2 mm.) (CB)				1		1				28	11	3
Indeterminate (>2 mm.) (R)	1									2		
Indeterminate (<2 mm.) (R)												
Seaweed (LF)												
Moss fragments (carbonised LF)												
Indeterminate seed/fruit (S/F)	1		1			2			2	51	3	
Indeterminate (trigonous) (S/F)					3	1				6		
Indeterminate pericarp fragment (PF)					1							
Total wild	5	4	5	2	13	22	3	2	5	432	21	3
Total QC	11	34	42	14	631	86	103	508	280	1769	68	20
QC/litre	0.8	3.4	4.2	0.7	45.1	3.6	7.4	72.6	28.0	15.8	4.9	0.2
caryopsis/litre	0.4	3.0	3.6	0.5	44.1	2.6	7.1	72.3	27.5	11.6	3.2	0.2
% grain	54.5	88.2	85.7	78.6	97.9	73.3	97.1	99.6	98.2	73.4	66.2	75.0
% chaff	0.0	0.0	2.4	7.1	0.0	1.2	0.0	0.0	0.0	2.1	2.9	10.0
% wild	45.5	11.8	11.9	14.3	2.1	25.6	2.9	0.4	1.8	24.4	30.9	15.0

Table B15h: Macrofossil counts for Bostadh 'figure-of-eight' block (**BO-LIA**); wild components

sample	156	158	57	101	133	130	128	134	136	177	308	309
context	264	263	123	200	249	248	164	148	148	319	879	884
context type	FL	FL	M	OL	AS	M	FL	FL	FL	NFF	NFF	NFF
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA
Volume (litres)	28	11	84	14	14	21	14	28	84	28	14	84
Wild species												
Ajuga reptans L. (S)					1							
Arctostaphylos uva-ursi (L.) Sprengel (F)												
Brassica cf. *rapa* L. (S)					1	1		1		1		
Brassica/Sinapis spp. (S)					2	1	1	1	13	3		1
Calluna vulgaris (L.) Hull. (Cap)					1							
Calluna vulgaris (L.) Hull. (LF)			1F								3F	
Carex spp. (biconvex) (N)		3	1		6	5			3			
Carex spp. (trigonous) (N)	1	6	6		11				1		1	
Chenopodium album L. (S)					3	4		1	1			
Chenopodium/Atriplex spp. (S)												
Corylus avellana L. (NF)												
Danthonia decumbens L. (C)			1		1							
Eleocharis palustris L. (N)		1			4	1	1		1		1	2
Empetrum nigrum L. (F)					1							
Erica tetralix L. (LF)					5F							
Erica/Calluna spp. (C)			2		1				2			
Fallopia convolvulus L. A. Love (N)												
Fumaria officanalis L. (F)					1							
Galeopsis tetrahit L. (N)												
Galium aparine L. (N)												
Montia fontana L. (S)											1	
Persicaria lapathifolia (L.) Gray (N)					3							
Persicaria maculosa Gray (N)												
Plantago lanceolata L. (S)					6				1			1
Poa cf. *annua* L. (C)												
Poaceae (small) undiff. (C)		2			3	1			1			
Poaceae undiff. (large) (C)		1			6				2			
Poaceae undiff. (medium) (C)		1	1		20	2		1	3		2	
Polygonum aviculare L. (N)		2										
Polygonum spp. (N)		1			4		2			1		
Pteridium aquilinium (L.) Kuhn (LF)									1F			
Ranunculus bulbosus L. (A)												
Ranunculus repens L. (A)					1							
Ranunculus spp. (A)							1					
Raphanus raphanistrum L. (F)												
Rumex acetosa L. (N)												
Rumex acetosella L. (N)					2		1		1			
Rumex crispus L. (N)	1	5	4		4		1		3			1
Rumex spp. (N)			3						1	1		
Spergula arvensis L. (S)						1	2		2			
Stachys cf. *palustris* L. (F)					1				1			
Stellaria media (L.) Villars (S)								3		2		
Trifolium repens L. (S)										1		1
Urtica dioica L. (F)											1	
Viola sp. (S)												
Cereal/monocotyledon (<2 mm.) (CN)		3	1		18	1			8		1	2
Cereal/monocotyledon (<2 mm.) (CB)	5	21	38	2	53	29		3	8	1	1	4
Indeterminate (>2 mm.) (R)		1	6		14	1			1			1
Indeterminate (<2 mm.) (R)					3	1						
Seaweed (LF)												4F
Moss fragments (carbonised LF)												
Indeterminate seed/fruit (S/F)		3	10		21	7	2		6	2	2	1
Indeterminate (trigonous) (S/F)		3			6							
Indeterminate pericarp fragment (PF)												
Total wild	7	53	73	2	198	55	11	10	59	12	10	14
Total QC	24	100	280	26	902	101	65	22	263	35	25	63
QC/litre	0.9	9.1	3.3	1.9	64.4	4.8	4.6	0.8	3.1	1.3	1.8	0.8
caryopsis/litre	0.4	3.1	1.7	1.6	46.1	1.3	3.9	0.3	2.2	0.8	0.9	0.4
% grain	50.0	34.0	49.6	88.5	71.5	27.7	83.1	40.9	69.2	65.7	48.0	52.4
% chaff	20.8	13.0	24.3	3.8	6.5	17.8	0.0	13.6	8.4	0.0	12.0	25.4
% wild	29.2	53.0	26.1	7.7	22.0	54.5	16.9	45.5	22.4	34.3	40.0	22.2

Table B15i: Macrofossil counts for Bostadh 'figure-of-eight' block (**BO-LIA**); wild components continued

sample	313	317	323	324	138	144	150	166	170.1	170.2	246	287
context	885/2	885/3	885/6	885/7	226	227	230	317	318.a	318.b	659	362
context type	NFF	NFF	NFF	NFF	OL	OL	OL	NFF	HM	HM	NFF	HM
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA
Volume (litres)	14	14	14	14	28	28	14	14	14	14	14	92
Wild species												
Ajuga reptans L. (S)												
Arctostaphylos uva-ursi (L.) Sprengel (F)												
Brassica cf. *rapa* L. (S)			1						17			1
Brassica/Sinapis spp. (S)	2	1			4	1	2		2		1	2
Calluna vulgaris (L.) Hull. (Cap)												
Calluna vulgaris (L.) Hull. (LF)	7F											
Carex spp. (biconvex) (N)												3
Carex spp. (trigonous) (N)	4		1		1		1					8
Chenopodium album L. (S)			1									1
Chenopodium/Atriplex spp. (S)												
Corylus avellana L. (NF)												
Danthonia decumbens L. (C)												1
Eleocharis palustris L. (N)			2						1			
Empetrum nigrum L. (F)												
Erica tetralix L. (LF)												
Erica/Calluna spp. (C)	1											
Fallopia convolvulus L. A. Love (N)												
Fumaria officanalis L. (F)												
Galeopsis tetrahit L. (N)	1											
Galium aparine L. (N)									1			
Montia fontana L. (S)												
Persicaria lapathifolia (L.) Gray (N)			2									1
Persicaria maculosa Gray (N)			1									1
Plantago lanceolata L. (S)												1
Poa cf. *annua* L. (C)												
Poaceae (small) undiff. (C)												
Poaceae undiff. (large) (C)			3						6			3
Poaceae undiff. (medium) (C)			2				1	1	2			7
Polygonum aviculare L. (N)									1			1
Polygonum spp. (N)			2									1
Pteridium aquilinium (L.) Kuhn (LF)												
Ranunculus bulbosus L. (A)												
Ranunculus repens L. (A)												
Ranunculus spp. (A)			1									
Raphanus raphanistrum L. (F)												
Rumex acetosa L. (N)									1			
Rumex acetosella L. (N)												5
Rumex crispus L. (N)			2		1				1			3
Rumex spp. (N)				1								3
Spergula arvensis L. (S)												6
Stachys cf. *palustris* L. (F)			1									1
Stellaria media (L.) Villars (S)												1
Trifolium repens L. (S)			2									
Urtica dioica L. (F)												2
Viola sp. (S)												
Cereal/monocotyledon (<2 mm.) (CN)	2		2			1						3
Cereal/monocotyledon (<2 mm.) (CB)	6	1	13						1		1	28
Indeterminate (>2 mm.) (R)				1								2
Indeterminate (<2 mm.) (R)					1							2
Seaweed (LF)												
Moss fragments (carbonised LF)			5F									
Indeterminate seed/fruit (S/F)	2		6		1	2			3			8
Indeterminate (trigonous) (S/F)	1					1		1				3
Indeterminate pericarp fragment (PF)												
Total wild	19	2	42	2	8	5	4	2	36	0	2	98
Total QC	63	52	586	125	17	10	15	12	1577	20	10	447
QC/litre	4.5	3.7	41.9	8.9	0.6	0.4	1.1	0.9	112.6	1.4	0.7	4.9
caryopsis/litre	2.8	3.6	38.7	8.8	0.1	0.2	0.7	0.7	110.0	1.4	0.6	3.6
% grain	61.9	96.2	92.5	98.4	11.8	50.0	66.7	83.3	97.7	100.0	80.0	73.8
% chaff	7.9	0.0	0.3	0.0	41.2	0.0	6.7	0.0	0.1	0.0	0.0	4.3
% wild	30.2	3.8	7.2	1.6	47.1	50.0	26.7	16.7	2.3	0.0	20.0	21.9

Table B15j: Macrofossil counts for Bostadh 'figure-of-eight' block (**BO-LIA**); wild components continued

sample	318	319	320	328	331	124.1	151	?	176	91	?	253
context	887	891	889	890	888	173	221	315	358	174	314	498
context type	NFF	NFF	NFF	NFF	HM	FL	FL	FL	NFF	M	M	OL
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA
Volume (litres)	7	7	14	14	28	238	336	14	8	56	14	14
Wild species												
Ajuga reptans L. (S)												
Arctostaphylos uva-ursi (L.) Sprengel (F)												
Brassica cf. *rapa* L. (S)						1						
Brassica/Sinapis spp. (S)	1			2			2	4	3			
Calluna vulgaris (L.) Hull. (Cap)												
Calluna vulgaris (L.) Hull. (LF)		2F		4F								
Carex spp. (biconvex) (N)				4	3	1					1	
Carex spp. (trigonous) (N)				1	7	2		3		2		
Chenopodium album L. (S)												
Chenopodium/Atriplex spp. (S)					1							
Corylus avellana L. (NF)												
Danthonia decumbens L. (C)		1		3								
Eleocharis palustris L. (N)				1				1				
Empetrum nigrum L. (F)												
Erica tetralix L. (LF)												
Erica/Calluna spp. (C)										1		
Fallopia convolvulus L. A. Love (N)				1								
Fumaria officanalis L. (F)												
Galeopsis tetrahit L. (N)				1								
Galium aparine L. (N)												
Montia fontana L. (S)												
Persicaria lapathifolia (L.) Gray (N)												
Persicaria maculosa Gray (N)												
Plantago lanceolata L. (S)		1	1	1	2					1		4
Poa cf. *annua* L. (C)												
Poaceae (small) undiff. (C)					1							
Poaceae undiff. (large) (C)			5	3		1	4				1	
Poaceae undiff. (medium) (C)	3		2	3	2		8	3			1	
Polygonum aviculare L. (N)			1									
Polygonum spp. (N)						1						
Pteridium aquilinium (L.) Kuhn (LF)												
Ranunculus bulbosus L. (A)						1						
Ranunculus repens L. (A)				2								
Ranunculus spp. (A)				1								
Raphanus raphanistrum L. (F)							1					
Rumex acetosa L. (N)												
Rumex acetosella L. (N)					2	1	2	1				
Rumex crispus L. (N)	1				1	1	11	13				
Rumex spp. (N)				1			1	2				
Spergula arvensis L. (S)												
Stachys cf. *palustris* L. (F)						1						
Stellaria media (L.) Villars (S)							4					
Trifolium repens L. (S)						1						
Urtica dioica L. (F)	1											
Viola sp. (S)												
Cereal/monocotyledon (<2 mm.) (CN)			3	6	33			3		3		1
Cereal/monocotyledon (<2 mm.) (CB)	1	10	7	34	50	2	1	4	1	12	1	14
Indeterminate (>2 mm.) (R)				4	4		2			4	1	8
Indeterminate (<2 mm.) (R)				4						3		
Seaweed (LF)	1F							1000+F				
Moss fragments (carbonised LF)												
Indeterminate seed/fruit (S/F)	3	2	1	6	3	2	1	5	1	3		3
Indeterminate (trigonous) (S/F)					2					1	1	
Indeterminate pericarp fragment (PF)										1		
Total wild	11	14	20	78	111	15	37	39	5	31	6	30
Total QC	31	31	64	157	261	91	130	326	23	91	25	36
QC/litre	4.4	4.4	4.6	11.2	9.3	0.4	0.4	23.3	2.9	1.6	1.8	2.6
caryopsis/litre	2.9	2.1	2.6	3.6	2.4	0.3	0.3	19.6	2.1	0.6	1.0	0.0
% grain	64.5	48.4	57.8	32.5	26.1	73.6	66.2	84.4	73.9	37.4	56.0	0.0
% chaff	0.0	6.5	10.9	17.8	31.4	9.9	5.4	3.7	4.3	28.6	20.0	16.7
% wild	35.5	45.2	31.3	49.7	42.5	16.5	28.5	12.0	21.7	34.1	24.0	83.3

Table B15k: Macrofossil counts for Bostadh 'figure-of-eight' block (**BO-LIA**); wild components continued

sample	232	187	198	207	211	226	248	249	250	251	261	284
context	481	439	464	445	287	479	471	466	493	471	714	714
context type	M	OL	NFF	NFF	M	AS	OL	OL	NFF	OL	AS	AS
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA
Volume (litres)	28	28	21	14	31	3	42	42	14	14	9	21
Wild species												
Ajuga reptans L. (S)												
Arctostaphylos uva-ursi (L.) Sprengel (F)							1					4
Brassica cf. *rapa* L. (S)						1					1	2
Brassica/Sinapis spp. (S)								7				
Calluna vulgaris (L.) Hull. (Cap)			2									
Calluna vulgaris (L.) Hull. (LF)			15F									1F
Carex spp. (biconvex) (N)	2				2	2						
Carex spp. (trigonous) (N)			1			3						1
Chenopodium album L. (S)						1						8
Chenopodium/Atriplex spp. (S)								2				1
Corylus avellana L. (NF)												
Danthonia decumbens L. (C)							1	1				
Eleocharis palustris L. (N)			6					1				3
Empetrum nigrum L. (F)							2					
Erica tetralix L. (LF)						4F						
Erica/Calluna spp. (C)			1					1				2
Fallopia convolvulus L. A. Love (N)					1							
Fumaria officanalis L. (F)												
Galeopsis tetrahit L. (N)					1						1	
Galium aparine L. (N)												
Montia fontana L. (S)												
Persicaria lapathifolia (L.) Gray (N)												11
Persicaria maculosa Gray (N)												
Plantago lanceolata L. (S)			1									
Poa cf. *annua* L. (C)												
Poaceae (small) undiff. (C)	2		1			2				1		
Poaceae undiff. (large) (C)			1		1	2		5				
Poaceae undiff. (medium) (C)	1				1							
Polygonum aviculare L. (N)			1									2
Polygonum spp. (N)												12
Pteridium aquilinium (L.) Kuhn (LF)												
Ranunculus bulbosus L. (A)												
Ranunculus repens L. (A)			1									1
Ranunculus spp. (A)												
Raphanus raphanistrum L. (F)												
Rumex acetosa L. (N)												
Rumex acetosella L. (N)												
Rumex crispus L. (N)	3		3	3	2	1		44				8
Rumex spp. (N)						1		3		1		13
Spergula arvensis L. (S)								2			3	2
Stachys cf. *palustris* L. (F)												
Stellaria media (L.) Villars (S)								1				
Trifolium repens L. (S)												
Urtica dioica L. (F)												4
Viola sp. (S)												
Cereal/monocotyledon (<2 mm.) (CN)	4			1		2	1	4				14
Cereal/monocotyledon (<2 mm.) (CB)	4	2	18		2		2	8	1			10
Indeterminate (>2 mm.) (R)		3			1			7	1	2	1	1
Indeterminate (<2 mm.) (R)			1			1						
Seaweed (LF)			5F									
Moss fragments (carbonised LF)												
Indeterminate seed/fruit (S/F)	3		1		3	8		6		1		10
Indeterminate (trigonous) (S/F)	4			1	3		4				3	5
Indeterminate pericarp fragment (PF)			6									
Total wild	23	5	44	5	17	24	11	92	2	5	9	114
Total QC	57	14	70	11	55	35	32	167	17	23	145	516
QC/litre	2.0	0.5	3.3	0.8	1.8	11.7	0.8	4.0	1.2	1.6	16.1	24.6
caryopsis/litre	1.0	0.3	1.0	0.2	1.0	3.0	0.4	1.6	1.0	1.3	15.1	18.7
% grain	49.1	57.1	30.0	27.3	58.2	25.7	56.3	39.5	82.4	78.3	93.8	76.0
% chaff	10.5	7.1	7.1	27.3	10.9	5.7	9.4	5.4	5.9	0.0	0.0	1.9
% wild	40.4	35.7	62.9	45.5	30.9	68.6	34.4	55.1	11.8	21.7	6.2	22.1

Table B15L: Macrofossil counts for Bostadh 'figure-of-eight' block (**BO-LIA**); wild components continued

sample	288	297	298	299	300	325	326	327	330	137	238	221
context	742	717	744	748	743	738	753	751	749	285	531	518
context type	HM	M	HM	HM	HM	HM	NFF	NFF	HM	M	OL	OL
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA
Volume (litres)	14	28	14	14	21	28	28	56	14	65	28	14
Wild species												
Ajuga reptans L. (S)												
Arctostaphylos uva-ursi (L.) Sprengel (F)												
Brassica cf. *rapa* L. (S)			2		2							
Brassica/Sinapis spp. (S)			8	3	6		1		1	2	1	
Calluna vulgaris (L.) Hull. (Cap)							1					
Calluna vulgaris (L.) Hull. (LF)							7F	2F				
Carex spp. (biconvex) (N)										1		
Carex spp. (trigonous) (N)				1	1					1		
Chenopodium album L. (S)			3	1	3							
Chenopodium/Atriplex spp. (S)				1	1							
Corylus avellana L. (NF)			2	1	1							
Danthonia decumbens L. (C)							2					
Eleocharis palustris L. (N)					5		3					
Empetrum nigrum L. (F)												1
Erica tetralix L. (LF)												
Erica/Calluna spp. (C)								1				
Fallopia convolvulus L. A. Love (N)												
Fumaria officanalis L. (F)												
Galeopsis tetrahit L. (N)												
Galium aparine L. (N)							1					
Montia fontana L. (S)												
Persicaria lapathifolia (L.) Gray (N)				1	1		1					
Persicaria maculosa Gray (N)												
Plantago lanceolata L. (S)			1	1								
Poa cf. *annua* L. (C)					1							
Poaceae (small) undiff. (C)							4			6		
Poaceae undiff. (large) (C)			5	16	3	4	10					
Poaceae undiff. (medium) (C)			2		1	3	30			4		
Polygonum aviculare L. (N)					1							
Polygonum spp. (N)			2	7	2	1	1					
Pteridium aquilinium (L.) Kuhn (LF)							1F	5F				
Ranunculus bulbosus L. (A)												
Ranunculus repens L. (A)												
Ranunculus spp. (A)				1				1				
Raphanus raphanistrum L. (F)												
Rumex acetosa L. (N)												
Rumex acetosella L. (N)			2	1	2		2					
Rumex crispus L. (N)			2	1	3		2		2	6		
Rumex spp. (N)			2	2	2							
Spergula arvensis L. (S)					2	2	48					
Stachys cf. *palustris* L. (F)												
Stellaria media (L.) Villars (S)												
Trifolium repens L. (S)												
Urtica dioica L. (F)			2			2	5					
Viola sp. (S)												
Cereal/monocotyledon (<2 mm.) (CN)		1	1		1		6	20		4		
Cereal/monocotyledon (<2 mm.) (CB)		5					38	49	1	20		1
Indeterminate (>2 mm.) (R)							1	2		1		
Indeterminate (<2 mm.) (R)								6		1		
Seaweed (LF)												
Moss fragments (carbonised LF)												
Indeterminate seed/fruit (S/F)		2	8	3	12	5	41	4		4	2	
Indeterminate (trigonous) (S/F)					4	2	1	1	1		1	
Indeterminate pericarp fragment (PF)					4		1					
Total wild	0	8	42	40	58	19	199	84	5	50	4	2
Total QC	16	22	1157	1176	1204	253	1838	445	219	115	12	12
QC/litre	1.1	0.8	82.6	84.0	57.3	9.0	65.6	7.9	15.6	1.8	0.4	0.9
caryopsis/litre	1.1	0.4	79.6	81.1	54.5	8.3	57.5	5.8	15.3	0.6	0.3	0.7
% grain	100.0	54.5	96.3	96.6	95.0	91.7	87.6	72.4	97.7	34.8	58.3	83.3
% chaff	0.0	9.1	0.1	0.0	0.2	0.8	1.5	8.8	0.0	21.7	8.3	0.0
% wild	0.0	36.4	3.6	3.4	4.8	7.5	10.8	18.9	2.3	43.5	33.3	16.7

Table B15m: Macrofossil counts for Bostadh 'figure-of-eight' block (**BO-LIA**); wild components continued

sample	276	277	279	281	282	200	280	247	
context	575	574	583	570	584	513	581	537	
context type	NFF	HM	NFF	NFF	NFF	AS	OL	OL	
block	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	
Volume (litres)	14	28	14	14	14	35	7	35	
Wild species									
Ajuga reptans L. (S)									1
Arctostaphylos uva-ursi (L.) Sprengel (F)									5
Brassica cf. *rapa* L. (S)				1					38
Brassica/Sinapis spp. (S)							1		85
Calluna vulgaris (L.) Hull. (Cap)									4
Calluna vulgaris (L.) Hull. (LF)						3F			0
Carex spp. (biconvex) (N)						2			49
Carex spp. (trigonous) (N)	2	2				1			81
Chenopodium album L. (S)	2	1	1						34
Chenopodium/Atriplex spp. (S)	1	17							24
Corylus avellana L. (NF)									4
Danthonia decumbens L. (C)		1							12
Eleocharis palustris L. (N)	3				1			1	50
Empetrum nigrum L. (F)									6
Erica tetralix L. (LF)									0
Erica/Calluna spp. (C)									12
Fallopia convolvulus L. A. Love (N)									2
Fumaria officanalis L. (F)									2
Galeopsis tetrahit L. (N)									4
Galium aparine L. (N)									2
Montia fontana L. (S)									4
Persicaria lapathifolia (L.) Gray (N)									24
Persicaria maculosa Gray (N)									2
Plantago lanceolata L. (S)							1		29
Poa cf. *annua* L. (C)									1
Poaceae (small) undiff. (C)				1	1				32
Poaceae undiff. (large) (C)	1	2							95
Poaceae undiff. (medium) (C)	3						1		218
Polygonum aviculare L. (N)		1							11
Polygonum spp. (N)	1	1							49
Pteridium aquilinium (L.) Kuhn (LF)									0
Ranunculus bulbosus L. (A)									1
Ranunculus repens L. (A)									5
Ranunculus spp. (A)			1						6
Raphanus raphanistrum L. (F)									1
Rumex acetosa L. (N)									3
Rumex acetosella L. (N)	1			1					34
Rumex crispus L. (N)	5	2	4	1		4		2	174
Rumex spp. (N)			1				1		44
Spergula arvensis L. (S)	2								169
Stachys cf. *palustris* L. (F)		1							6
Stellaria media (L.) Villars (S)									18
Trifolium repens L. (S)									5
Urtica dioica L. (F)									44
Viola sp. (S)									6
Cereal/monocotyledon (<2 mm.) (CN)	3	3		1		1		1	184
Cereal/monocotyledon (<2 mm.) (CB)	13	14			3	7	5	2	601
Indeterminate (>2 mm.) (R)						1			74
Indeterminate (<2 mm.) (R)		3							26
Seaweed (LF)									1
Moss fragments (carbonised LF)									0
Indeterminate seed/fruit (S/F)	7	4			1	2	2		295
Indeterminate (trigonous) (S/F)	3	3			1	1		1	68
Indeterminate pericarp fragment (PF)									13
Total wild	47	55	7	5	7	19	11	7	2658
Total QC	122	304	29	16	53	32	87	22	
QC/litre	8.7	10.9	2.1	1.1	3.8	0.9	12.4	0.6	
caryopsis/litre	4.7	7.8	1.6	0.8	3.2	0.3	10.4	0.4	
% grain	54.1	71.4	75.9	68.8	84.9	28.1	83.9	68.2	
% chaff	7.4	10.5	0.0	0.0	1.9	12.5	3.4	0.0	
% wild	38.5	18.1	24.1	31.3	13.2	59.4	12.6	31.8	

Table B15n: Macrofossil counts for Bostadh 'figure-of-eight' block (**BO-LIA**); wild components continued

Sample	86/3	86/7	86/2	87/2	
Context	15	17	10	83	
Block	LB-LIA	LB-LIA	LB-LIA	LB-LIA	
Generic context type	FL	HM	M	NFF	
Volume (litres)	7	8	5	6	**Totals**
Grain					
Hordeum sp. (C)	1	3	2	11	17
H. hulled (C)	1		6	20	27
H. cf. Hulled (C)				8	8
H. hulled symmetric (C)			3	9	12
H. hulled asymmetric (C)		2	4	21	27
Triticum sp. (C)				1	1
Avena sp. (C)				4	4
Linum usitasitissimum L. (S)		20		12	32
Cereal indeterminate (C)			1	8	9
Total grain	2	25	16	94	137
Chaff					
Cereal/monocotyledon (>2 mm.) (CB)	3		3	1	7
Total chaff	3	0	3	1	7
Wild species					
Brassica/Sinapis spp. (S)	1				1
Calluna vulgaris (L.) Hull. (Cap)				5	5
Carex spp. (biconvex) (N)	1				1
Carex spp. (trigonous) (N)	1				1
Persicaria maculosa Gray (N)	2			1	3
Poaceae undiff. (medium) (C)		2			2
Polygonum spp. (N)	1	1			2
Rumex acetosa L. (N)				1	1
Rumex acetosella L. (N)				1	1
Rumex crispus L. (N)		1			1
Spergula arvensis L. (S)		1		1	2
Stellaria media (L.) Villars (S)		1			1
Cereal/monocotyledon (<2 mm.) (CB)	3		1		4
Indeterminate (>2 mm.) (R)		1	1		2
Indeterminate seed/fruit (S/F)	2	2		6	10
Total wild	11	9	2	15	37
Total QC	16	34	21	110	
QC/litre	2.3	4.3	4.2	18.3	
caryopsis/litre	0.3	3.1	3.2	15.7	
% grain	12.5	73.5	76.2	85.5	
% chaff	18.8	0.0	14.3	0.9	
% wild	68.8	26.5	9.5	13.6	

Table B16: Macrofossil counts for Loch na Beirgh 'figure-of-eight' block (**LB-LIA**)

sample	135	185	206	208	210	258	260	92	93	107
context	284	432	285	443	461	707	711	99	101	107
context type	OL	M	M	FL	M	M	HM	M	OL	M
block	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N
Volume (litres)	14	14	140	56	21	14	3	28	14	56
Hordeum sp. (C)	3	46	79	12	57	9	1	3	4	26
H. naked (C)		2	2		2					
H. cf. Naked (C)				3			1			2
H. naked symmetric (C)		2	2		2					
H. naked asymmetric (C)		2	6							
H. hulled (C)	3	10	47	8	25	3	2	12	13	239
H. cf. Hulled (C)	1	4	21	8	14	5	1	5		75
H. hulled symmetric (C)	2	8	16	5	8		1	9	4	15
H. hulled asymmetric (C)	3	7	27	8	23	4			6	30
Triticum sp. (C)			1						1	3
Avena sp. (C)			40	1	1			25		12
Linum sp. (S)						1		4		
Cereal indeterminate (C)	1	26	35	6	39	10	2		3	32
Total grain	13	107	276	51	171	32	8	58	31	434
H. *vulgare* L. (RI)				4						
H. cf. *distichon* L. (RI)										
A. *sativa* L. (FB)										
Cereal/monocotyledon (>2 mm.) (CN)		1	1	1						2
Cereal/monocotyledon (>2 mm.) (CB)	3	2	56	2	21	1		2		6
Total chaff	3	3	57	7	21	1	0	2	0	8
Brassica cf. *rapa* L. (S)		1	4					1		
Brassica/Sinapis spp. (S)			3					2		
Calluna vulgaris (L.) Hull. (Cap)			1							
Calluna vulgaris (L.) Hull. (LF)			5F		5F					
Carex spp. (biconvex) (N)			6							
Carex spp. (trigonous) (N)			20							1
Chenopodium album L. (S)			2							
Chenopodium/Atriplex spp. (S)										
Danthonia decumbens L. (C)			3							
Eleocharis palustris L. (N)			2	3						
Empetrum nigrum L. (F)			1							
Erica/Calluna spp. (C)										
Fallopia convolvulus L. A. Love (N)										
Plantago lanceolata L. (S)			3			1				2
Poaceae (small) undiff. (C)			2		1	1				
Poaceae undiff. (large) (C)										
Poaceae undiff. (medium) (C)				2		1				1
Polygonum aviculare L. (N)			4	1		1	3			
Polygonum spp. (N)			4	1		1		2	1	1
Potentilla erecta (L.) Raeusch (S)										
Ranunculus bulbosus L. (A)										
Ranunculus repens L. (A)			2							
Ranunculus spp. (A)			1							
Raphanus raphanistrum L. (F)			1							
Rumex acetosa L. (N)			4							
Rumex acetosella L. (N)			6			2				
Rumex crispus L. (N)		5	50	7		15		1		1
Rumex spp. (N)		2	4	2		2				1
Spergula arvensis L. (S)		1	1							
Stellaria media (L.) Villars (S)		1	1							
Vaccinium myrtillus L. (S)										
Viola sp. (S)			1							
Cereal/monocotyledon (<2 mm.) (CN)		2	40	1	1	1				1
Cereal/monocotyledon (<2 mm.) (CB)	1	1	181	16	28	15			2	4
Indeterminate (>2 mm.) (R)			24	4	2	1		1		
Indeterminate (<2 mm.) (R)			11	3						
Indeterminate seed/fruit (S/F)		5	16	1		5		1		2
Indeterminate (trigonous) (S/F)			17	1					1	
Indeterminate pericarp fragment (PF)			2							
Seaweed (LF)								1F		
Lichen (foliose) (LF)										
Total wild	1	18	417	42	32	46	3	8	4	14
Total QC	17	128	750	100	224	79	11	68	35	456
QC/litre	1.2	9.1	5.4	1.8	10.7	5.6	3.7	2.4	2.5	8.1
caryopsis/litre	0.9	7.6	2.0	0.9	8.1	2.3	2.7	2.1	2.2	7.8
% grain	76.5	83.6	36.8	51.0	76.3	40.5	72.7	85.3	88.6	95.2
% chaff	17.6	2.3	7.6	7.0	9.4	1.3	0.0	2.9	0.0	1.8
% wild	5.9	14.1	55.6	42.0	14.3	58.2	27.3	11.8	11.4	3.1

Table B17a: Macrofossil counts for **BO-LIA/N**

sample	111	124.2	129	131	132	140	181	186	205	74
context	98	114	120	280	282	112	431	435	441	40
context type	M	M	FL	M	OL	M	M	M	M	AS
block	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N
Volume (litres)	14	28	14	14	14	224	84	56	84	14
Hordeum sp. (C)		1				127	42	3	24	47
H. naked (C)										
H. cf. Naked (C)							4		1	13
H. naked symmetric (C)						1				
H. naked asymmetric (C)										
H. hulled (C)	8	17	9	15	16	184	5		5	19
H. cf. Hulled (C)	2	2	4	4	3	69	4	1	2	10
H. hulled symmetric (C)			1	3		79	5	1	3	11
H. hulled asymmetric (C)	2		1		4	108	3	3	2	23
Triticum sp. (C)						4				
Avena sp. (C)		3				9				3
Linum sp. (S)									1	
Cereal indeterminate (C)	2	1				62	21	2	12	9
Total grain	14	24	15	22	23	643	84	10	50	135
H. *vulgare* L. (RI)						3	1			
H. cf. *distichon* L. (RI)						1				
A. *sativa* L. (FB)						2				
Cereal/monocotyledon (>2 mm.) (CN)						1	5		1	
Cereal/monocotyledon (>2 mm.) (CB)				1		23	33	3	57	1
Total chaff	0	0	0	1	0	30	39	3	58	1
Brassica cf. *rapa* L. (S)						1				1
Brassica/Sinapis spp. (S)								2		
Calluna vulgaris (L.) Hull. (Cap)										
Calluna vulgaris (L.) Hull. (LF)						1F				
Carex spp. (biconvex) (N)										
Carex spp. (trigonous) (N)						3	1	1		
Chenopodium album L. (S)								2		
Chenopodium/Atriplex spp. (S)							1			
Danthonia decumbens L. (C)						1		2		
Eleocharis palustris L. (N)										
Empetrum nigrum L. (F)									1	
Erica/Calluna spp. (C)			1							
Fallopia convolvulus L. A. Love (N)			1							
Plantago lanceolata L. (S)										
Poaceae (small) undiff. (C)										1
Poaceae undiff. (large) (C)						3	2			
Poaceae undiff. (medium) (C)		1	1			2	1	1		
Polygonum aviculare L. (N)										
Polygonum spp. (N)						2	1	1	1	
Potentilla erecta (L.) Raeusch (S)										
Ranunculus bulbosus L. (A)							1			
Ranunculus repens L. (A)										
Ranunculus spp. (A)										
Raphanus raphanistrum L. (F)										
Rumex acetosa L. (N)									1	
Rumex acetosella L. (N)						1				
Rumex crispus L. (N)		3	1			3	6	1	17	
Rumex spp. (N)							2	1		
Spergula arvensis L. (S)										
Stellaria media (L.) Villars (S)						1		2		
Vaccinium myrtillus L. (S)				1						
Viola sp. (S)							1			
Cereal/monocotyledon (<2 mm.) (CN)	1		1	1		15	10	2	11	
Cereal/monocotyledon (<2 mm.) (CB)				1		16	94	2	27	2
Indeterminate (>2 mm.) (R)						12	17	1	43	1
Indeterminate (<2 mm.) (R)		1					7		1	
Indeterminate seed/fruit (S/F)			2	2		11	3	1	1	1
Indeterminate (trigonous) (S/F)						2				
Indeterminate pericarp fragment (PF)										
Seaweed (LF)		1F								
Lichen (foliose) (LF)						1F				
Total wild	1	5	7	5	0	73	147	19	103	6
Total QC	15	29	22	28	23	746	270	32	211	142
QC/litre	1.1	1.0	1.6	2.0	1.6	3.3	3.2	0.6	2.5	10.1
caryopsis/litre	1.0	0.9	1.1	1.6	1.6	2.9	1.0	0.2	0.6	9.6
% grain	93.3	82.8	68.2	78.6	100.0	86.2	31.1	31.3	23.7	95.1
% chaff	0.0	0.0	0.0	3.6	0.0	4.0	14.4	9.4	27.5	0.7
% wild	6.7	17.2	31.8	17.9	0.0	9.8	54.4	59.4	48.8	4.2

Table B17b: Macrofossil counts for **BO-LIA/N** continued

sample	86	87	227	242	274	311	
context	19	33	523	33	523/519	586	
context type	OL	AS	OL	AS	OL	M	
block	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	
Volume (litres)	28	14	14	14	14	28	
Hordeum sp. (C)	12	127	4	37	3	4	671
H. naked (C)							6
H. cf. Naked (C)		4					28
H. naked symmetric (C)							7
H. naked asymmetric (C)							8
H. hulled (C)	19	33	1	36	2	3	734
H. cf. Hulled (C)	7	13		12	2		269
H. hulled symmetric (C)	5	28	1	8	2		215
H. hulled asymmetric (C)	9	55	1	11			330
Triticum sp. (C)		1					10
Avena sp. (C)	8	7		1			110
Linum sp. (S)						1	7
Cereal indeterminate (C)	1	29	2	60	4	34	393
Total grain	61	297	9	165	13	42	2788
H. *vulgare* L. (RI)							8
H. cf. *distichon* L. (RI)							1
A. *sativa* L. (FB)							2
Cereal/monocotyledon (>2 mm.) (CN)	1	1		1			15
Cereal/monocotyledon (>2 mm.) (CB)	1	1		1	1	4	219
Total chaff	2	2	0	2	1	4	245
Brassica cf. *rapa* L. (S)							8
Brassica/Sinapis spp. (S)	1						8
Calluna vulgaris (L.) Hull. (Cap)						1	2
Calluna vulgaris (L.) Hull. (LF)				1F		1F	0
Carex spp. (biconvex) (N)						2	8
Carex spp. (trigonous) (N)						1	27
Chenopodium album L. (S)		1					5
Chenopodium/Atriplex spp. (S)							1
Danthonia decumbens L. (C)						2	8
Eleocharis palustris L. (N)							5
Empetrum nigrum L. (F)							2
Erica/Calluna spp. (C)						2	3
Fallopia convolvulus L. A. Love (N)							1
Plantago lanceolata L. (S)							6
Poaceae (small) undiff. (C)						1	6
Poaceae undiff. (large) (C)	1					1	7
Poaceae undiff. (medium) (C)	1						11
Polygonum aviculare L. (N)	1						10
Polygonum spp. (N)							15
Potentilla erecta (L.) Raeusch (S)						1	1
Ranunculus bulbosus L. (A)							1
Ranunculus repens L. (A)							2
Ranunculus spp. (A)							1
Raphanus raphanistrum L. (F)							1
Rumex acetosa L. (N)							5
Rumex acetosella L. (N)							9
Rumex crispus L. (N)	2		1		1	1	115
Rumex spp. (N)							14
Spergula arvensis L. (S)	1						3
Stellaria media (L.) Villars (S)							5
Vaccinium myrtillus L. (S)							1
Viola sp. (S)							2
Cereal/monocotyledon (<2 mm.) (CN)							87
Cereal/monocotyledon (<2 mm.) (CB)		1			1		392
Indeterminate (>2 mm.) (R)	2					1	109
Indeterminate (<2 mm.) (R)						2	25
Indeterminate seed/fruit (S/F)	1		1	1		4	58
Indeterminate (trigonous) (S/F)	1						22
Indeterminate pericarp fragment (PF)							2
Lichen (foliose) (LF)							0
Total wild	11	2	2	1	2	19	988
Total QC	74	301	11	168	16	65	
QC/litre	2.6	21.5	0.8	12.0	1.1	2.3	
caryopsis/litre	2.2	21.2	0.6	11.8	0.9	1.5	
% grain	82.4	98.7	81.8	98.2	81.3	64.6	
% chaff	2.7	0.7	0.0	1.2	6.3	6.2	
% wild	14.9	0.7	18.2	0.6	12.5	29.2	

Table B17c: Macrofossil counts for **BO-LIA/N** continued

sample	8	14	26/27	29	30	32	33	34	36	39	78	
context	20	26	53	59	56	58	60	60	64	53	59	
context type	FL	M	M	M	M	M	M	M	M	M	M	
block	BO-N	BO-N	BO-N	BO-N	BO-N	BO-N	BO-N	BO-N	BO-N	BO-N	BO-N	
Volume (litres)	14	24	70	42	14	42	14	56	14	14	14	
Grain												**Total**
Hordeum sp. (C)	3	2	79		4	14	8	17	200	22	4	353
H. cf. naked (C)			6		1	3		1		3	2	16
H. hulled (C)	4	3	76	4	3	12	4	23	110	29	5	273
H. cf. Hulled (C)			16		2	3	2	7	74	12	3	119
H. hulled symmetric (C)			15			3	2	4	36	3		63
H. hulled asymmetric (C)		3	35			8	1	14	42	8	5	116
Triticum sp. (C)			2	2								4
Avena sp. (C)	1		139		10	4	3		152	33	1	343
Secale cereale L. (C)			2							1		3
Linum sp. (S)			6			3		1		2		12
Cereal indeterminate (C)	3		36		4		4	11	154	16	3	231
Total grain	11	8	412	6	24	50	24	78	768	129	23	1533
Chaff												
A. *sativa* L. (FB)									1			1
Cereal/monocotyledon (>2 mm.) (CB)		7	2		1	20		4	5	1		40
Total chaff	0	7	2	0	1	20	0	4	6	1	0	41
Wild species												
Arctostaphylos uva-ursi (L.) Sprengel (F)						1			1			2
Brassica cf. *rapa* L. (S)						1		1				2
Brassica/Sinapis spp. (S)						1			2			3
Carex spp. (trigonous) (N)		1	2									3
Chenopodium album L. (S)						1			1			2
Chenopodium/Atriplex spp. (S)			1			1						2
Danthonia decumbens L. (C)			1									1
Empetrum nigrum L. (F)			1									1
Galium aparine L. (N)		1					1					2
Plantago lanceolata L. (S)									2			2
Poaceae (small) undiff. (C)						1						1
Poaceae undiff. (large) (C)		1				4		1	1			7
Poaceae undiff. (medium) (C)					2			1	3			6
Polygonum aviculare L. (N)			1			1			2			4
Polygonum spp. (N)						3			1			4
Ranunculus bulbosus L. (A)									1			1
Ranunculus repens L. (A)									1			1
Ranunculus spp. (A)			1									1
Rumex acetosella L. (N)								1				1
Rumex crispus L. (N)		1	4			9		2				16
Rumex spp. (N)			1					1				2
Spergula arvensis L. (S)						9			2	1		12
Stachys cf. *palustris* L. (F)												0
Vaccinium myrtillus L. (S)									1			1
Vicia sativa L.			1									1
Cereal/monocotyledon (<2 mm.) (CN)					1	1					1	3
Cereal/monocotyledon (<2 mm.) (CB)		2		6	1	2	3	1				15
Indeterminate (>2 mm.) (R)			7			3		1	6		1	18
Indeterminate (<2 mm.) (R)				2		2						4
Indeterminate seed/fruit (S/F)			6	1		12	1	5	1	2		28
Indeterminate (trigonous) (S/F)			5						1			6
Seaweed (LF)			1F									
Total wild	0	6	31	9	4	52	5	14	26	3	2	152
Total QC	11	21	445	15	29	122	29	96	800	133	25	
QC/litre	0.8	0.9	6.4	0.4	2.1	2.9	2.1	1.7	57.1	9.5	1.8	
caryopsis/litre	0.8	0.3	5.9	0.1	1.7	1.2	1.7	1.4	54.9	9.2	1.6	
% grain	100.0	38.1	92.6	40.0	82.8	41.0	82.8	81.3	96.0	97.0	92.0	
% chaff	0.0	33.3	0.4	0.0	3.4	16.4	0.0	4.2	0.8	0.8	0.0	
% wild	0.0	28.6	7.0	60.0	13.8	42.6	17.2	14.6	3.3	2.3	8.0	

Table B18: Macrofossil counts for Bostadh Norse block (**BO-N**)

Sample	2	3	4	10	13	51	52	53	55	57	
Context	165	166	147	205	140	112b	133	134	114	131	
Block	GAL-N/M	GAL-N/M	GAL-N/M	GAL-N/M	GAL-N/M	GAL-N/M	GAL-N/M	GAL-N/M	GAL-N/M	GAL-N/M	
Generic context type	M	M	HM	FL	M	AS	M	M	M	FL	
Volume (litres)	7	7	7	4	4	2	3	2	3	3	**Total**
Grain											
Hordeum sp. (C)	248	3	1		4		2	3	12	4	277
H. naked symmetric (C)	3						3				6
H. hulled (C)	304	2	2	2					9	5	324
H. cf. Hulled (C)	120	1		1				1	5	3	131
H. hulled symmetric (C)	128	1	1			1	1		4		136
H. hulled asymmetric (C)	212	1					3		1		217
Avena sp. (C)	258	1		1	2		2	3	1	1	269
Triticum sp. (C)						1			1	1	3
Secale cereale L. (C)	2										2
Linum usitassitissimum L. (S)										1	1
Cereal indeterminate (C)	340	5	3	3	4		1	3	28	11	398
Grain total	1615	14	7	7	10	2	12	10	61	26	1764
Chaff											
Hordeum sp. (RI)		2					1				3
H. *vulgare* L. (RI)	10					1			1		12
H. *distichon* L. (RI)	2										2
A. *sativa* L. (FB)	1										1
Cereal indeterminate (AF)										1F	0
Cereal/monocotyledon (>2 mm.) (CN)	20								1	1	22
Cereal/monocotyledon (>2 mm.) (CB)	15										15
Chaff total	48	2	0	0	0	1	1	0	2	1	55
Wild species											
Atriplex spp. (S)	2										2
Atriplex hastata L. (S)	1						1				2
Betula sp. (S)									1		1
Brassica cf. *rapa* L. (S)	26										26
Brassica/Sinapis spp. (S)	2					1					3
Carex spp. (biconvex) (N)	14						1	1			16
Carex spp. (trigonous) (N)	19					1					20
Chenopodium/Atriplex spp. (S)	3		1				3		1		8
Chenopodium album L. (S)	4		1								5
Danthonia decumbens L. (C)	12										12
Erica/Calluna spp. (Cap)	1										1
Montia fontana L. (S)	2						1				3
Plantago lanceolata L. (S)	2										2
Poaceae undiff. (large) (C)	9										9
Poaceae undiff. (medium) (C)	13						1		2		16
Poaceae (small) undiff. (C)	1			1			1	2	1		6
Polygonum spp. (N)	2									1	3
Ranunculus acris L. (A)	1										1
Ranunculus bulbosus L. (A)	1										1
Rumex acetosella L. (N)	3										3
Rumex crispus L. (N)	14							1			15
Rumex spp. (N)	1		1	1				1	1		5
Spergula arvensis L. (S)	2										2
Stellaria media (L.) Villars (S)	5		2				2		1	2	12
Urtica dioica L. (F)	1										1
Cereal/monocotyledon (<2 mm.) (CN)	9	1					1				11
Cereal/monocotyledon (<2 mm.) (CB)	22	4					1		1		28
Indeterminate (>2 mm.) (R)	3		3			2				1	9
Indeterminate (<2 mm.) (R)	9	3	2	4		10			2		30
Indeterminate seed/fruit (S/F)	29					2	2	1	2	5	41
Indeterminate (trigonous) (S/F)	16										16
Total wild	229	8	10	6	0	16	14	6	12	9	310
Moss fragment (carbonised LF)							1F				0
Total QC	1892	24	17	13	10	19	27	16	75	36	
QC/litre	270.3	3.4	2.4	3.3	2.5	9.5	9.0	8.0	25.0	12.0	
caryopsis/litre	230.7	2.0	1.0	1.8	2.5	1.0	4.0	5.0	20.3	8.7	
% grain	85.4	58.3	41.2	53.8	100.0	10.5	44.4	62.5	81.3	72.2	
% chaff	2.5	8.3	0.0	0.0	0.0	5.3	3.7	0.0	2.7	2.8	
% wild	12.1	33.3	58.8	46.2	0.0	84.2	51.9	37.5	16.0	25.0	

Table B19: Macrofossil counts for Galson Norse / early Medieval block (**GAL-N/M**)

Sample	5	9	37	
Context	5	20	45	
Block	AD-M	AD-M	AD-M	
Volume (litres)	28	28	21	
Generic context ype	OL	AS	AS	**Totals**
Grain				
Hordeum sp. (C)	1			1
H. cf. hulled (C)	1			1
H. hulled asymmetric (C)			1	1
Avena sp. (C)	1		49	50
Cereal indeterminate (C)			6	6
Total grain	3	0	56	59
Chaff				
Cereal/monocotyledon (>2 mm.) (CN)		1	4	5
Cereal/monocotyledon (>2 mm.) (CB)		4	3	7
Total chaff	0	5	7	12
Wild species				
Carex spp. (trigonous) (N)		1		1
Danthonia decumbens L. (C)			3	3
Eleocharis palustris L. (N)			1	1
Plantago lanceolata L. (S)			1	1
Poaceae undiff. (large) (C)	1		1	2
Polygonum spp. (N)			1	1
Polygonum aviculare L. (N)			3	3
Ranunculus spp. (A)		1		1
Cereal/monocotyledon (<2 mm.) (CN)		2		2
Cereal/monocotyledon (<2 mm.) (CB)	2	15	4	21
Indeterminate (>2 mm.) (R)	5	11	5	21
Indeterminate (<2 mm.) (R)	6	35	4	45
Indeterminate seed/fruit (S/F)	7		3	10
Total wild	21	65	26	112
Total QC	24	70	89	183
QC/litre	0.86	2.50	4.24	
caryopsis/litre	0.11	0.00	2.67	
% grain	12.5	0.0	62.9	
% chaff	0.0	7.1	7.9	
% wild	87.5	92.9	29.2	

Table B20: Macrofossil counts for An Dunan early Medieval block (**AD-M**)

Charcoal identifications for all the samples

NB: Identifications are shown by number of fragments (x) and weight (w) by genera / species in the following xF (w).

Context	123	198	200	203			121	122	125	129	134	135	177	180	181	182		
Phase	CC-1	CC-1	CC-1	CC-1			CC-3	CC-3	CC-3	CC-3	CC-3	CC-3	CC-3	CC-3	CC-3	CC-3		
Generic context type	NFF	NFF	NFF	NFF			AS	AS	NFF	AS	AS	AS	AS	AS	AS	AS		
Volume (litres)	4	2	1	1	Total	%	43	17	9	13	5	22	11	17	18	16	Total	%
Deciduous roundwood																		
Betula sp. roundwood					0.00	0.0								0.05	0.06		0.11	1.7
Corylus sp. roundwood					0.00	0.0					0.06		0.19	0.20	0.09		0.54	8.1
Salix sp. roundwood					0.00	0.0	0.15			0.13			0.17		0.15		0.60	9.0
Deciduous timber																		
Betula sp.					0.00	0.0	0.12		0.12	0.17	0.05	0.08	0.02			1.92	2.48	37.3
Corylus sp.		0.03			0.03	12.5	0.05			0.02		0.02	0.03		0.02	2.77	2.91	43.8
Quercus sp.					0.00	0.0						0.19					0.19	2.9
Salix sp.	0.08		0.09	0.04	0.21	87.5		0.06	0.03	0.07		0.03	0.19			0.69	1.07	16.1
Total weight	0.08	0.03	0.09	0.04	0.24		0.17	0.06	0.15	0.26	0.05	0.32	0.24	0.00	0.02	5.38	6.65	

Table B21: Charcoal identifications (weight only) for Calanais kerb cairn (**CC-1 & CC-3**)

Sample	5	10	11	12	13	14	16	18	19	20	21	23	24
Context	8	14	25	28	29	30	35	41	42	43	44	47	52
Phase	1	1	1	1	1	1	1	2	1	2	2	3	3
Block	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE
Context type	OL	OL	OL	OL	OL	OL	NFF	OL	OL	OL	OL	NFF	NFF
Volume (litres)	28	28	28	28	28	28	56	28	28	28	42	56	10.5
Total fragments in fraction	12	16	23	10	19	22	18	8	20	4	9	20	4
Total fragments	12	16	23	10	19	22	18	8	84	4	9	58	4
% id	100	100	100	100	100	100	100	100	24	100	100	34	100
Deciduous roundwood													
Alnus sp. roundwood					1F(0.01)								
Bark roundwood												1F(0.12)	
Betula sp. roundwood		2F(0.17)	4F(0.35)		2F(0.48)	5F(0.17)	5F(0.35)	2F(0.13)	6F(1.37)			1F(0.2)	
Calluna vulgaris (L.) roundwood	3F(0.28)	4F(0.27)	2F(0.19)		1F(0.18)	7F(0.14)	1F(0.03)		3F(0.23)		1F(0.04)	10F(0.32)	
Corylus sp. roundwood							1F(0.1)		1F(0.07)				
Pomoideae undiff. roundwood				3F(0.39)		1F(0.05)			1F(0.09)				
Deciduous timber													
Alnus sp.			4F(0.28)										
Betula sp.	1F(0.1)	3F(0.09)	2F(0.02)	6F(0.46)	3F(0.38)	1F(0.02)	2F(0.11)		4F(0.27)		6F(1.17)		1F(0.08)
Fraxinus sp.					1F(0.15)								
Quercus sp.								1F(0.03)	1F(0.04)				
Coniferous roundwood													
Pinus sp. roundwood													1F(0.09)
Coniferous timber													
Larix sp.					1F(0.81)								
Picea sp.		1F(0.05)											
Pinus sp.	2F(0.14)	3F(0.35)	5F(0.16)	1F(0.03)	4F(0.35)	3F(0.1)	3F(0.25)	2F(0.4)		1F(0.08)	1F(0.03)		
Indeterminate													
Indet. roundwood/rootwood	2F(0.16)	2F(0.06)	1F(0.01)		5F(0.25)	3F(0.16)	1F(0.05)	1F(0.04)	3F(0.32)		1F(0.06)	8F(0.45)	2F(0.23)
Indet.	4F(0.32)	1F(0.05)	5F(0.41)		1F(0.47)	2F(0.12)	2F(0.2)	2F(0.16)	1F(0.11)	3F(0.3)			
Bark fragment							3F(0.45)						
Total for fraction													
Total fragments in flot	12	16	23	10	19	22	18	8	84	4	9	58	4
Total weight	1.00	1.04	1.42	0.88	3.18	0.76	1.54	0.76	14.16	0.38	1.30	3.65	0.40

Table B22a: Charcoal identifications for Gob Eirer (**GE**)

Sample	25	28	33	37	38	39	40	42	44	45	47	48	49
Context	60	67	76	85	84	92	91	86	94	95	96	83	97
Phase	1	2	2	2	2	2	2	2	2	2	2	2	2
Block	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE	GE
Context type	OL	OL	OL	OL	OL	FL	AS	FL	AS	FL	FL	OL	FL
Volume (litres)	28	28	28	28	28	14	28	5	14	56	28	28	28
Total fragments in fraction	12	5	1	4	6	4	11	5	1	3	1	1	11
Total fragments	12	5	1	4	6	4	11	5	1	3	1	1	11
% id	100	100	100	100	100	100	100	100	100	100	100	100	100
Deciduous roundwood													
Alnus sp. roundwood													
Bark roundwood													
Betula sp. roundwood						1F(0.04)	2F(0.12)	1F(0.07)				1F(0.4)	1F(0.07)
Calluna vulgaris (L.) roundwood	9F(0.4)	2F(0.3)						2F(0.1)	1F(0.06)				4F(0.12)
Corylus sp. roundwood								1F(0.06)		3F(0.15)			
Pomoideae undiff. roundwood	1F(0.01)							1F(0.09)					
Deciduous timber													
Alnus sp.					1F(0.02)								
Betula sp.							2F(0.03)						
Fraxinus sp.													
Quercus sp.				2F(0.08)									
Coniferous roundwood													
Pinus sp. roundwood													
Coniferous timber													
Larix sp.													
Picea sp.							3F(0.08)						
Pinus sp.				1F(0.05)	1F(0.15)	1F(0.1)	2F(0.12)				1F(0.12)		1F(0.05)
Indeterminate													
Indet. roundwood/rootwood	2F(0.21)	2F(0.09)			3F(0.13)		1F(0.06)						5F(0.25)
Indet.		1F(0.06)	1F(0.09)	1F(0.07)	1F(0.06)	2F(0.12)	1F(0.12)						
Bark fragment													
Total for fraction													
Total fragments in flot	12	5	1	4	6	4	11	5	1	3	1	1	11
Total weight	0.62	0.45	0.09	0.20	0.36	0.26	0.53	0.32	0.06	0.15	0.12	0.40	0.49

Table B22b: Charcoal identifications for Gob Eirer (**GE**)

Context	158	206	165	210	131a	128	169	174	181	186	137B
Block	DB-P	DB-M	DB-S	DB-S	DB-S	DB-S	DB-S	DB-S	DB-S	DB-S	DB-S
Generic context type	OL	OL	HM	HM	HM	CON	CON	CON	CON	CON	CON
Volume (litres)	5	5	5	5	5	Hand	5	Hand	Hand	Hand	Hand
Total fragments in fraction	28	2	1	4	2		132	145	113	130	180
Total fragments in flot	28	2	1	4	2		528	145	113	130	180
% id	100	100	100	100	100		25	100	100	100	100
Deciduous roundwood											
Betula sp. (birch) roundwood	2F (10.19)						2F (0.03)			16F (4.17)	
Calluna vulgaris (L.) Hull (Ling heather) roundwood	17F (0.71)	1F (0.01)		4F (0.12)			8F (0.57)				4F (0.48)
Deciduous timber											
Corylus sp. (hazel)					1F (0.02)						
Coniferous roundwood											
Pinus sp. Roundwood											
Coniferous timber											
Picea sp. (spruce)					1F (0.03)	24F (45.5)	59F (14.75)	23F (4.64)		25F (3.31)	73F (35.76)
Pinus sp. (pine)	1F (0.01)	1F (0.01)	1F (0.01)			43F (65.91)	46F (3.83)	122F (45.47)	113F (122.46)	105F (13.95)	103F (63.29)
Pinus sp. (pine) bark							3F (0.6)				
Indeterminate											
Indeterminate rootwood	6F (0.21)										
Indeterminate roundwood											
Indeterminate fragments	2F (0.08)						14F (1.07)				

Table B23: Charcoal identifications for Dun Bharabhat (**DB-P, DB-M & DB-M**)

Sample	63	70	20	22	90	91	xx	11	24	32
Context	187	201	90	103	279	280	266	71	71	153
Phase	5	5	11	8	8	8	8	10	10	13
Block	CN-W	CN-W	CN-W	CN-C	CN-C	CN-C	CN-C	CN-C	CN-C	CN-C
Generic context type	AS	FL	AS	OL	AS	HM	FL	OL	OL	OL
Volume (litres)	3.0	1.0	1.0	2.0	2.0	3.0	2.5	2.0	1.5	1.5
Total fragments in fraction	1	4	30	10	20	30	7	2	20	1
Total fragments	1	4	30	10	68	30	7	2	27	1
% id	100	100	100	100	30	100	100	100	74	100
Deciduous roundwood										
Betula sp. Roundwood					16F(0.4)			1F(0.04)		
Corylus sp. Roundwood										
Salix sp. Roundwood				10F(0.23)		20F(1.26)		1F(0.05)	2F(0.05)	1F(0.01)
Deciduous timber										
Quercus sp.										
Salix type		4F(0.11)				10F(0.36)				
Coniferous roundwood										
Pinus sp. Roundwood			30F(1.26)						18F(0.65)	
Indeterminate										
Indet. Roundwood/rootwood	1F(0.02)				4F(0.05)		7F(0.59)			

Table B24a: Charcoal identifications for Cnip (**CN-W & CN-C**)

Sample	32	1	12	13	16	61
Context	153	20	43	83	83	166
Phase	13	1	1	1	1	20
Block	CN-C	CN-R	CN-R	CN-R	CN-R	CN-R
Generic context type	OL	FL	FL	FL	FL	NFF
Volume (litres)	1.5	3.5	2.0	2.0	7.0	2.0
Total fragments in fraction	1	6	52	2	3	4
Total fragments	1	6	52	2	3	4
% id	100	100	100	100	100	100
Deciduous roundwood						
Betula sp. Roundwood						
Corylus sp. Roundwood					3F(0.07)	
Salix sp. Roundwood	1F(0.01)	6F(0.19)	7F(0.08)			
Deciduous timber						
Quercus sp.			45F(2.61)			
Salix type						
Coniferous roundwood						
Pinus sp. Roundwood						
Indeterminate						
Indet. Roundwood/rootwood				2F(0.05)		4F(0.14)

Table B24b: Charcoal identifications for Cnip (**CN-R**)

Sample	9	12	26	37	38	42	47	55	73	92	94	96	97
Context	20	22	46	45	57	54	67	69	107	136	127	135	141
Block	AD-M	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA
Volume (litres)	28	28	28	21	11	14	42	28	21	28	28	28	28
Generic context type	AS	HM	AS	AS	AS	AS	AS	HM	AS	HM	HM	AS	AS
Total fragments in fraction	20	7	1	34	3	4	6	1	8	2	2	3	1
Total fragments	20	7	1	34	3	4	6	1	8	2	2	3	1
% id	100	100	100	100	100	100	100	100	100	100	100	100	100
Deciduous roundwood													
Alnus sp. Roundwood				2F(0.09)									
Bark roundwood													
Betula sp. Roundwood			1F(0.01)	1F(0.01)		3F(0.06)							
Calluna vulgaris (L.) roundwood	7F(0.3)			10F(0.35)	1F(0.11)			1F(0.05)	4F(0.35)	1F(0.03)	1F(0.04)		
Corylus sp. Roundwood		1F(0.04)		1F(0.02)					4F(0.37)			1F(0.03)	
Pomoideae undiff. Roundwood				4F(0.18)									
Prunus sp. Roundwood					2F(0.03)								
Rhamnus catharticus L.													
Deciduous timber													
Betula sp.													
Corylus sp.		2F(0.1)				1F(0.01)							
Quercus sp.				1F(0.01)									
Coniferous roundwood													
Pinus sp. Roundwood	2F(0.1)												
Coniferous timber													
Picea sp.	1F(0.03)			8F(0.74)									1F(0.04)
Pinus sp.	5F(0.16)			1F(0.15)			4F(0.06)						
Indeterminate													
Indet. Roundwood/rootwood	4F(0.21)	3F(0.09)		6F(0.14)			1F(0.02)			1F(0.02)	1F(0.04)		
Indet.	1F(0.03)	1F(0.03)					1F(0.02)					2F(0.05)	

Table B25a: Charcoal identifications for An Dunan (**AD-M & AD-IA**)

Sample	98	101	104	105	106	109	110	112	123	124	125	127
Context	142	147	128	154	155	151	152	159	166	167	177	181
Block	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA	AD-IA
Volume (litres)	28	28	10	9	21	14	56	28	28	28	28	28
Generic context type	AS	FL	HM	HM	HM	HM	HM	AS	AS	HM	FL	FL
Total fragments in fraction	3	5	2	2	1	6	3	3	5	1	1	1
Total fragments	3	5	2	2	1	6	3	3	5	1	1	1
% id	100	100	100	100	100	100	100	100	100	100	100	100
Deciduous roundwood												
Alnus sp. Roundwood												
Bark roundwood									1F(0.03)			
Betula sp. Roundwood		2F(0.14)				3F(0.14)						
Calluna vulgaris (L.) roundwood	3F(0.13)	1F(0.02)	2F(0.06)			1F(0.05)					1F(0.05)	1F(0.05)
Corylus sp. Roundwood									1F(0.08)			
Pomoideae undiff. Roundwood									1F(0.07)			
Prunus sp. Roundwood												
Rhamnus catharticus L.							1F(0.04)					
Deciduous timber												
Betula sp.						1F(0.03)						
Corylus sp.												
Quercus sp.												
Coniferous roundwood												
Pinus sp. Roundwood												
Coniferous timber												
Picea sp.												
Pinus sp.						1F(0.01)	1F(0.02)	2F(0.1)	2F(0.1)			
Indeterminate												
Indet. roundwood/rootwood		2F(0.08)		2F(0.14)	1F(0.02)		1F(0.04)	1F(0.03)		1F(0.02)		
Indet.												

Table B25b: Charcoal identifications for An Dunan (**AD-IA** continued)

Sample	243	245	253	272	307	308	311	341	349	350	365	376	388	393	397
Context	371	372	373	397	437	436	443	487	448	497	518	478	541	557	553
Block	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA	GUN-IA
Generic context type	AS	AS	FL	AS	HM	AS	HM	FL	FL	FL	FL	FL	HM	FL	OL
Volume (litres)	14	14	14	14	14	14	7	14	14	14	14	14	14	14	14
Total fragments in fraction	1	5	4	12	5	4	2	7	1	6	6	2	7	2	6
Total fragments	1	5	4	12	5	4	2	7	1	6	6	2	7	2	6
% id	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Deciduous roundwood															
Alnus sp. Roundwood						1F(0.02)									
Betula sp. Roundwood	1F(0.03)		1F(0.02)	5F(0.1)							3F(0.08)				1F(0.04)
Calluna vulgaris (L.) roundwood		2F(0.02)	2F(0.08)		1F(0.01)		1F(0.01)	3F(0.05)		1F(0.01)		2F(0.03)			4F(0.09)
Pomoideae undiff. Roundwood				1F(0.01)											
Salix sp. Roundwood				1F(0.02)											
Coniferous roundwood															
Junipersis sp. Roundwood		1F(0.03)								1F(0.01)					
Pinus sylvestris roundwood					1F(0.02)			1F(0.01)							
Coniferous timber															
Abies sp.													7F(0.72)		
Conifer indet.				1F(0.01)					1F(0.01)		1F(0.01)				
Larix sp.		2F(0.05)		2F(0.3)	3F(0.05)	2F(0.03)		3F(0.05)		2F(0.03)	1F(0.01)				
Picea sp.						1F(0.01)								2F(0.15)	
Pinus sp.			1F(0.01)				1F(0.01)								
Indeterminate															
Indet. roundwood/rootwood				2F(0.03)						2F(0.03)					1F(0.15)
Indet.											1F(0.01)				

Table B26: Charcoal identifications for Guinnerso (**GUN**)

Sample	344	100	89/3	169	204	94/5	94/9	171	206	94/8	230
Context	559	146	246	426	469	426	442	438a	470	438b	462
Block	LB-R	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C
Generic context type	M	M	M	FL	FL	FL	NFF	HM	HM	HM	FL
Volume (litres)	161	n/a	5	2	10	14	14	14	4.5	14	56
Total fragments in fraction	20	25	15	1	16	7	8	20	17	21	20
Total fragments in flot	1851	25	15	1	16	7	8	93	17	21	138
% id	1	100	100	100	100	100	100	22	100	100	14
Deciduous roundwood											
Alnus sp. Roundwood											
Bark roundwood					1F(0.02)						
Betula sp. Roundwood	3F(0.16)				3F(0.13)		2F(0.02)	1F(0.03)	1F(0.02)		1F(0.03)
Calluna vulgaris (L.) roundwood	8F(0.4)	19F(1.00)	10F(0.46)		7F(0.1)	3F(0.14)	3F(0.07)	11F(0.72)	12F(0.3)	19F(0.64)	9F(0.39)
Corylus sp. Roundwood	1F(0.04)		1F(0.04)					2F(0.15)	2F(0.02)		1F(0.05)
Pomoideae undiff. Roundwood	1F(0.12)	1F(0.02									
Deciduous timber											
Alnus sp.											
Betula sp.		1F(0.02)				2F(0.03)					4F(0.27)
Corylus sp.			1F(0.04)								
Pomoideae undiff.											
Salix sp.											
Coniferous timber											
Abies sp.			1F(0.03)		1F(0.03)						
Larix sp.											
Picea sp.	1F(0.01)						2F(0.02)	1F(0.01)			1F(0.05)
Pinus sp.		1F(0.01)	1F(0.01)	1F(0.02)	1F(0.02)			1F(0.01)			
Pseudotsoga taxifolia L.											
Indeterminate											
Bark fragment						1F(0.03)					
Indet. roundwood/rootwood	6F(0.18)	2F(0.12)			3F(0.15)		1F(0.02)	2F(0.04)	2F(0.02)	2F(0.02)	4F(0.08)
Indet.		1F(0.01)	1F(0.01)			1F(0.01)		2F(0.05)			

Table B27a: Charcoal identifications for Loch na Beirgh (**LB-R & LB-C**)

Sample	257	236	361	240	295	322	229	366	379	305	241	325
Context	522	507	577	509	540	552	503	580	578	541	515	555
Block	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C	LB-C
Generic context type	NFF	HM	HM	M	M	HM	HM	HM	HM	FL	FL	NFF
Volume (litres)	14	56	28	11	11	28	28	14	28	56	28	49
Total fragments in fraction	20	20	20	20	6	20	20	15	20	20	20	20
Total fragments in flot	37	243	28	226	6	28	80	15	130	36	43	124
% id	54	8	71	9	100	71	25	100	15	56	47	16
Deciduous roundwood												
Alder sp. Roundwood						1F(0.06)					1F(0.03)	
Bark roundwood				2F(0.03)								
Betula sp. Roundwood		7F(0.29)				5F(0.12)	1F(0.03)		1F(0.03)	1F(0.02)	6F(0.29)	3F(0.15)
Calluna vulgaris (L.) roundwood	6F(0.3)	8F(0.26)	9F(0.36)	7F(0.31)	1F(0.03)	3F(0.09)	6F(0.2)	8F(0.18)	10F(0.38)	8F(0.4)		6F(0.12)
Corylus sp. Roundwood	3F(0.11)	1F(0.04)							2F(0.07)	2F(0.04)	4F(0.09)	5F(0.4)
Pomoideae undiff. Roundwood								1F(0.05)		1F(0.03)		
Deciduous timber												
Alnus sp.											1F(0.11)	
Betula sp.	2F(0.05)		5F(0.06)	3F(0.09)	2F(0.05)		3F(0.05)	2F(0.04)	1F(0.07)	3F(0.05)	2F(0.03)	1F(0.01)
Corylus sp.												
Pomoideae undiff.				1F(0.21)								
Salix sp.								1F(0.01)				
Coniferous timber												
Abies sp.						1F(0.02)				1F(0.02)	1F(0.03)	
Larix sp.								1F(0.01)				
Picea sp.					1F(0.03)	3F(0.11)		1F(0.01)		1F(0.02)	3F(0.07)	
Pinus sp.	3F(1.11)		1F(0.02)		1F(0.02)		5F(0.07)				2F(0.04)	1F(0.01)
Pseudotsoga taxifolia L.		1F(0.16)										
Indeterminate												
Bark fragment	1F(0.02)		1F(0.01)			1F(0.02)		1F(0.02)	1F(0.01)			
Indet. roundwood/rootwood	4F(0.21)	3F(0.05)	4F(0.1)	7F(0.83)	1F(0.03)	4F(0.1)	5F(0.09)		5F(0.08)	2F(0.03)		3F(0.08)
Indet.	1F(0.1)					2F(0.2)				1F(0.01)		1F(0.02)

Table B27b: Charcoal identifications for Loch na Beirgh (**LB-C continued**)

Sample	89/5	89/6	89/7	86/3	86/7	86/2
Context	250	251	267	15	17	10
Block	LB-I	LB-I	LB-I	LB-LIA	LB-LIA	LB-LIA
Generic context type	NFF	NFF	NFF	FL	HM	M
Volume (litres)	0.5	2	2	7	8	5
Total fragments in fraction	1	9	4	15	11	7
Total fragments in flot	1	9	4	15	11	7
% id	100	100	100	100	100	100
Deciduous roundwood						
Alnus sp. Roundwood						
Bark roundwood						
Betula sp. Roundwood				2F(0.09)		1F(0.03)
Calluna vulgaris (L.) roundwood		3F(0.08)	3F(0.09)	4F(0.15)	4F(0.2)	1F(0.06)
Corylus sp. Roundwood				1F(0.06)		
Pomoideae undiff. Roundwood						
Deciduous timber						
Alnus sp.						
Betula sp.					1F(0.04)	
Corylus sp.						
Pomoideae undiff.						
Salix sp.						
Coniferous timber						
Abies sp.						1F(0.03)
Larix sp.						
Picea sp.						
Pinus sp.			1F(0.03)			
Pseudotsoga taxifolia L.						
Indeterminate						
Bark fragment						
Indet. roundwood/rootwood	1F(0.04)	4F(0.14)		5F(0.16)	5F(0.18)	
Indet.		2F(0.06)		3F(0.06)	1F(0.05)	3F(0.05)

Table B27c: Charcoal identifications for Loch na Beirgh (**LB-I & LB-LIA**)

Sample	5	6	2	3	10	55	57
Context	300	301	165	166	205	114	131
Block	GAL-LIA	GAL-LIA	GAL-N/M	GAL-N/M	GAL-N/M	GAL-N/M	GAL-N/M
Generic context type	FL	FL	M	M	FL	M	FL
Volume (litres)	4	4	7	7	4	3	3
Total fragments in fraction	2	10	13	3	1	1	5
Total fragments	2	10	13	3	1	1	5
% id	100	100	100	100	100	100	100
Deciduous roundwood							
Betula sp. Roundwood		2F(0.04)				1F(0.04)	
Calluna vulgaris (L.) roundwood		2F(0.04)	1F(0.04)				4F(0.14)
Deciduous timber							
Alnus sp.			3F(0.08)				
Betula sp.			2F(0.07)				1F(0.03)
Corylus sp.			2F(0.05)				
Quercus sp.		1F(0.01)					
Coniferous timber							
Abies sp.					1F(0.06)		
Picea sp.			2F(0.02)				
Pinus sp.	2F(0.04)	2F(0.04)	3F(0.25)	3F(0.18)			
Indeterminate							
Indet. Roundwood/rootwood		3F(0.05)					

Table B28: Charcoal identifications for Galson (**GAL-LIA & GAL-N/M**)

Sample	204	57	138	189	221	251	261	282	287	293
Context	632	123	226	623	518	471	714	584	362	868
context type	NFF	M	OL	M	M	OL	AS	NFF	HM	NFF
I/D?	y	y	n	y	y	y	y	y	y	y
PhD block	BO-E	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA	BO-LIA
Volume (litres)	35	84	28	21	31	14	9	14	92	10
Total fragments in fraction	2	15	3	4	1	3	3	1	2	3
Total fragments	2	15	3	4	1	3	3	1	2	3
% id	100	100	100	100	100	100	100	100	100	100
Deciduous roundwood										
Betula sp. Roundwood		1F(0.04)								
Calluna vulgaris (L.) roundwood	1F(0.06)	7F(0.2)	1F(0.02)	2F(0.04)				1F(0.04)	1F(0.02)	2F(0.03)
Corylus sp. Roundwood										
Pomoideae undiff. Roundwood										
Salix sp. Roundwood				1F(0.02)						
Deciduous timber										
Alnus sp.										
Betula sp.		1F(0.03)	1F(0.02)							
Corylus sp.										
Salix sp.										
Coniferous roundwood										
Pinus sp. Roundwood										
Coniferous timber										
Coniferae undiff.		1F(0.03)				3F(0.03)			1F(0.02)	
Larix sp.							3F(0.06)			
Picea sp.					1F(0.04)					
Pinus sp.		5F(0.25)								1F(0.02)
Indeterminate										
Bark fragment	1F(0.02)									
Indet. roundwood/rootwood				1F(0.02)						
Indet.										
Seaweed			1F(0.01)							

Table B29a: Charcoal identifications for Bostadh (**BO-E & BO-LIA**)

Sample	92	93	129	131	132	135	205	210	258	311
Context	99	101	120	280	282	284	441	461	707	586
context type	M	OL	FL	M	OL	OL	M	M	M	M
I/D?	y	y	y	y	y	y	y	y	y	y
PhD block	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N	BO-LIA/N
Volume (litres)	28	14	14	14	14	14	84	21	14	28
Total fragments in fraction	5	1	4	1	2	2	20	18	20	2
Total fragments	5	1	4	1	2	2	664	18	140	2
% id	100	100	100	100	100	100	3	100	14	100
Deciduous roundwood										
Betula sp. Roundwood	2F(0.04)						1F(0.02)			
Calluna vulgaris (L.) roundwood					2F(0.08)			10F(0.43)	6F(0.22)	
Corylus sp. Roundwood										
Pomoideae undiff. Roundwood			1F(0.02)							
Salix sp. Roundwood							3F(0.89)	1F(0.02)		
Deciduous timber										
Alnus sp.			2F(0.17)							
Betula sp.	2F(0.09)						2F(0.06)		2F(0.05)	
Corylus sp.										
Salix sp.										
Coniferous roundwood										
Pinus sp. Roundwood							3F(0.12)		1F(0.02)	
Coniferous timber										
Coniferae undiff.		1F(0.01)				1F(0.02)	1F(0.02)		2F(0.04)	
Larix sp.										2F(0.05)
Picea sp.							5F(0.14)		5F(0.14)	
Pinus sp.						1F(0.09)	5F(0.32)		1F(0.02)	
Indeterminate										
Bark fragment								2F(0.02)		
Indet. roundwood/rootwood	1F(0.01)		1F(0.02)					5F(0.17)	2F(0.05)	
Indet.				1F(0.02)					1F(0.02)	
Seaweed										

Table B29b: Charcoal identifications for Bostadh (**BO-LIA/N**)

Sample	14	29	32	34	36	39	26/27
Context	26	59	58	60	64	53	53
context type	M	M	M	M	M	M	M
I/D?	y	y	y	y	y	y	y
PhD block	BO-N	BO-N	BO-N	BO-N	BO-N	BO-N	BO-N
Volume (litres)	24	42	42	56	14	14	70
Total fragments in fraction	5	5	9	3	20	1	20
Total fragments	5	5	9	3	61	1	153
% id	100	100	100	100	33	100	13
Deciduous roundwood							
Betula sp. Roundwood	2F(0.06)		1F(0.02)		2F(0.05)	1F(0.25)	2F(0.07)
Calluna vulgaris (L.) roundwood		1F(0.04)	5F(0.28)	1F(0.02)	6F(0.27)		2F(0.06)
Corylus sp. Roundwood		1F(0.04)					2F(0.06)
Pomoideae undiff. Roundwood							
Salix sp. Roundwood							3F(0.1)
Deciduous timber							
Alnus sp.							
Betula sp.					3F(0.26)		3F(0.06)
Corylus sp.							1F(0.08)
Salix sp.							2F(0.21)
Coniferous roundwood							
Pinus sp. Roundwood							
Coniferous timber							
Coniferae undiff.					1F(0.02)		1F(0.01)
Larix sp.		1F(0.08)			2F(0.05)		
Picea sp.					1F(0.02)		
Pinus sp.				1F(0.03)	1F(0.03)		
Indeterminate							
Bark fragment			1F(0.02)				2F(0.09)
Indet. roundwood/rootwood	2F(0.02)	2F(0.06)			4F(0.15)		
Indet.			2F(0.02)	1F(0.02)			2F(0.05)
Seaweed	1F(0.01)						

Table B29c: Charcoal identifications for Bostadh (**BO-N**)

Appendix C: Publications incorporating aspects of PhD research

Papers are photocopied from the journal or book and include the following;

Church, M J & Peters, C 2000 "Sedimentary analysis of soil samples. In D.W. Harding & T.N. Dixon, Dun Bharabhat, Cnip, an Iron Age settlement in West Lewis: Volume 1, structures and material culture", Edinburgh: University of Edinburgh, Calanais Research Monograph No. 2,114-119

Church, M J 2000 "Carbonised plant macrofossils and charcoal", *in* Harding, D W & Dixon, T N, *Dun Bharabhat, Cnip, an Iron Age settlement in West Lewis: Volume 1, structures and material culture,* Edinburgh: University of Edinburgh, Calanais Research Monograph No 2, 120-130

Peters, C, Church, M J & Coles, G M 2000 "Mineral magnetism and Archaeology at Galson on the Isle of Lewis, Scotland", *Physics and Chemistry of the Earth (A)* 25, 455-460

Peters, C, Church, M J & Mitchell, C 2001 "Investigation of domestic fuel sources on Lewis using mineral magnetism", *Archaeological Prospection* 8, 227-37

APPENDIX 2

SEDIMENTARY ANALYSIS OF SOIL SAMPLES

by
Mike Church (Department of Archaeology, University of Edinburgh)
Clare Peters (Department of Chemistry, University of Edinburgh)

Introduction

A series of routine soil tests and detailed mineral magnetic analysis were carried out for 20 sub-samples taken from the bulk samples removed during excavation. This report presents the results and discusses the implications for site formation processes and the preservation and taphonomy of ecofacts and artefacts, with particular reference to plant macrofossils.

Research basis

The samples were processed for doctoral research conducted by Mike Church to present a regional synthesis on the prehistoric use of plants in Lewis. This research is based on plant macrofossil assemblages recovered from over ten sites excavated by the University of Edinburgh, as part of the wider Calanais Archaeological Research Project (CARP). A number of recurrent research questions were formulated for the sedimentary analysis from each of these sites including;

1) Can basic sedimentary analysis help interpret differential preservation of ecofact and artefact types between sites?

2) Can basic sedimentary analysis give insights into generic site formation processes?

3) Can detailed mineral magnetic analysis of ash components on the site a) allow taphonomic models for carbonised plant macrofossils to be proposed and b) source the fuel types burnt in the hearths?

Methods

On-site sampling

A sub-sample of approximately 0.25 litres was removed from the bulk samples prior to wet-sieving. Hence, the sampling strategy reflects that of the bulk samples taken on site from 1985 and 1987. These were taken when the excavator deemed a context to be worthy of sampling, a strategy known as 'judgement sampling' (Jones 1991). 'Judgement sampling' does not statistically represent the sampled population (i.e. the archaeological contexts across the site) so the results presented in this report will be biased in the favour of stratigraphically important and perceived 'rich' contexts. However the 20 samples processed can present a general picture of preservation systems and site formation processes across the site, with more detailed information regarding the single contexts sampled.

Laboratory methodology

Each sub-sample was subjected to the following analyses; basic soil description (texture and colour), moisture and organic content, pH and mineral magnetic analysis. The methods employed for each test are described below.

1) Basic soil description

The basic physical characteristics of the 'wet' soil were described through texture and colour. The texture was estimated following Hodgson (1976) whilst the colour was estimated using Munsell colour charts (1992).

2) Moisture and organic content (following Hodgson 1976)

Approximately 20g. of 'wet' soil was dried at 40ºC for 24 hours before being dry sieved through a 2mm. gauge to remove stones and larger particles. The sieved material was then placed in a weighed crucible and placed in an oven at 100ºC for five minutes to drive off any latent moisture within the soil. The crucible and soil were then weighed before being placed in a furnace for four hours at a temperature of 550ºC, to incinerate the organic component. The crucible and material were then weighed and the percentage organic content (by weight) calculated.

3) pH (following Hodgson 1976)

The pH of the soil was measured using a Pye Unicam PW 9410 digital pH meter, calibrated to 7 and 4 pH buffer solutions. Approximately 20g. of 'wet' soil was added to 50ml. of distilled water. The solution was left for 20 minutes and periodically stirred. Then the probe of the meter was immersed in the solution for two minutes and a reading taken. Only one reading was taken from each sample owing to time constraints.

4) Magnetic susceptibility

The samples were dried at 40°C and dry sieved through a 2mm. gauge to remove stones and larger particles. Volumetric (κ) high and low frequency magnetic susceptibilities were measured with a Bartington MS2 meter and MS2 laboratory coil. Mass specific magnetic susceptibility (χlf) and percentage frequency dependent (κfd%) were then calculated following Dearing (1994).

Results and discussion

Tables 2 and 3 present the basic results from the sedimentary analysis. Some of the samples were labelled with both sample and context whereas others were simply labelled with a context. The results will be first analysed in terms of ecofact and artefact preservation, then generic site formation processes will be addressed before the detailed mineral magnetic analysis presented.

Site preservation systems

When analysing artefacts and ecofacts within a site assemblage, consideration must be given to the overall preservation environment of the site. Material such as pottery, stone, glass and carbonised plant macrofossils survive in the most hostile soil conditions but other material types, such as bone, require specific conditions for their preservation. Table 3 outlines the soil pH for all the sub-samples, with values ranging from 4.02 to 5.45 and a mean of 4.68. This acidic soil environment means very few fragments of uncarbonised bone and shell survived on the site, with only very resistant elements, such as teeth, occasionally surviving. The moisture and organic contents varied from very low values for the clay samples (such as S.87/3) to relatively high values for the more organic samples such as S.87/4. Within three of these more organic samples (S.87/4, S.87/6 and C.161) flecks of uncarbonised wood were recovered from the wet-sieving. This demonstrates that the soil conditions in certain contexts on the site were just on the threshold for uncarbonised plant macrofossil preservation as evidenced by the waterlogged levels at Dun Bharabhat and Loch na Beirgh (Church, 1996). However, the condition of the material from the land-based site at Dun Bharabhat was so poor that no identifications of the plants could be made.

Site formation processes

The samples cover a range of contexts that can be separated into groups of like formation, dependent on their context type and sample composition.

1) Destruction level

Only two bulk samples were taken from the secondary occupation destruction level; a sample of burnt plant material with no sediment component (C.169; see Appendix 3 for composition) and a sample of inorganic clay (C.137). Presumably the clay was either stored within the structural entity that was destroyed during the conflagration or was part of the structural entity itself. The magnetic susceptibility for the clay ($\chi lf = 0.42$) is higher than the low levels usually associated with natural clay from Lewis. This magnetic enhancement supports the conflagration interpretation, as sediments exposed to heat gain some enhancement (Peters *et al.*, in prep.)

2) Gallery fills

Two bulk samples (C.161, C.164) were taken from Gallery 4, associated with the secondary occupation. The low magnetic susceptibility values point to little domestic ash input into the sediments. Again C.164 probably represents collected natural clay, without the magnetic enhancement of the conflagration. The low magnetic susceptibility, pH and relatively high organic content of C.161 may point to predominantly natural infilling of the gallery for this sediment.

3) Construction material

Three samples were taken from structural elements of the secondary occupation of the site. Two samples (S.87/9 and S.87/3) comprised natural clay used for hearth foundation and wall bonding respectively. Both had limited magnetic enhancement similar to the clay within the destruction layer. Again this enhancement presumably stems from exposure to heat, the hearth foundation from *in situ* burning and the wall bonding perhaps from the conflagration. The third sample comes from the wall core of a secondary structure external to the main site. This material had the texture and colour of domestic ash, consistent with the very high magnetic susceptibility of the sample. Domestic ash and other domestic refuse are a common wall fill material from prehistoric structures through to post-Medieval blackhouses in the Western Isles. This mixture of material allows the wall core to maintain its moisture content and structure, an important consideration for drystone wall material (Jim Crawford, pers. comm.)

4) Hearth material

Four samples were taken from ashy material within and spilling from the central hearth, associated with the secondary occupation. All the samples consisted of ash, with high magnetic susceptibility, and presumably resulted from the final *in situ* burning within the hearth.

Three of the samples were subjected to more detailed mineral magnetic analysis, to source the fuel types used (*infra*).

5) Occupation

These occupation deposits consisted of interleaving lenses of material accumulated during occupation of the complex Atlantic roundhouse (CAR). Three samples were taken from the primary or pre-CAR occupation and seven samples were taken from the main CAR occupation. The samples displayed a wide variety in composition, even within the same context e.g. C.158. This reflects the variability in the sediments that would be deposited from activity within the structure. Therefore, there are samples relating to 1) the spread of ashy material from the central hearth (e.g. C.176 with higher values of magnetic susceptibility) 2) from the deposition of more organic material, as flooring for example (e.g. S.87/4 with high organic content and low magnetic susceptibility) and 3) occasional patches of natural clay (e.g. C.158a).

Taphonomic models for carbonised plant macrofossils

From the site stratigraphy and sedimentary analysis it is possible to propose two general taphonomic models for the preservation and subsequent dispersal of carbonised plant macrofossils across the site. The first involves the *in situ* burning represented by the destruction deposits and the hearth material. The second involves the subsequent removal and dispersal of the plant remains from the central hearth into the surrounding occupation deposits (cf. Peters *et al.*, 2000). This can take the form of deliberate cleaning of the hearth by the occupants or gradual incorporation of small amounts of ashy material into the surrounding floor levels over time.

Fuel sourcing

It is important to source the fuel types used on Atlantic Scottish sites for two reasons. Firstly, fuel was an important resource to be procured and managed as there was very little tree cover by the Iron Age in the Western Isles (Birks, 1994; Gilbertson *et al.*, 1996; Lomax and Edwards, this volume). Also, research has shown that different fuel types produce varying numbers and proportions of plant parts and species (McLaughlin, 1980; Dickson, 1998; Church *et al.*, in prep b). Therefore, in order to disentangle the fuel-derived plant macrofossils from those relating to use of plants by humans, it is necessary to apply a technique that can identify the dominant fuel source and then eliminate the corresponding macrofossils from further analysis.

Two techniques have been developed using laboratory-based mineral magnetic measurements for assessing fuel types from ash residues (Peters *et al.*, in prep.). The first technique is based on room temperature magnetic measurements; a discriminant analysis biplot has been produced from measurements of susceptibilities (initial and frequency dependent), anhysteretic remanent magnetisation and isothermal remanent magnetisations (cf. Thompson and Oldfield, 1986). The biplot shows the clear discrimination of wood and well-humified peat fuel types, with some overlap between fibrous-upper peat and peat turf. The second technique involves monitoring the variation of susceptibility as it is heated from room temperature up to 700°C and cooled back to room temperature. Fibrous-upper peat and peat turf show a characteristic single drop in susceptibility with heating at 600°C, whereas well-humified peat and wood display one, sometimes two, drops in susceptibility with heating at 330°C and/or 550°C.

The two techniques have been applied to four samples from Dun Bharabhat (see Figures 51 and 52). Samples with a high ash content were selected. These are from Contexts 131, 165, 210 (secondary occupation hearth material) and 176 (ash spread in main CAR occupation layers). The discriminant analysis biplot suggests that the ash spread, C176, is a mixture of well-humified peat and fibrous-upper peat/peat turf. The drop in susceptibility at approaching 600°C suggests that for the small sub-sample used in the high temperature measurements, fibrous-upper peat/peat turf is dominant. In comparison to C176, the high temperature susceptibility curves for the other three samples display drops in susceptibility at significantly lower temperatures, suggesting well-humified peat/wood. The positioning of these three samples on the discriminant analysis biplot is interesting. They show a similar trend to the well-humified peat ash, but are plotting further to the right than the experimental data. Comparison to ash deposits from the Cnip wheelhouse complex and Beirgh, both on the Bhaltos Peninsula (Church *et al.*, in

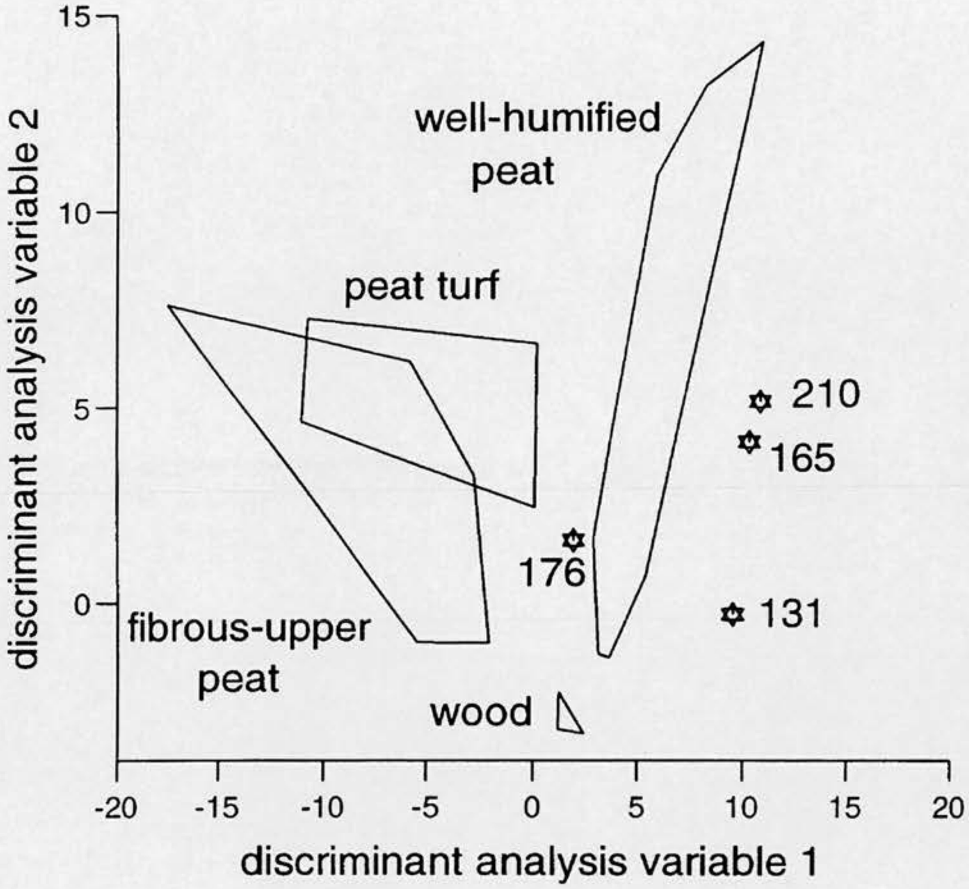


Figure 51: Discriminant analysis of four peat samples

prep.a), suggests that we are observing a very localised use of fuel sources.

Therefore, from the small number of samples analysed, well-humified peat seems to be the dominant fuel source with peaty turf also burnt. Peaty turf could be obtained from very close to the site, judging by the widespread heathland component in the pollen diagram (Lomax and Edwards, this volume). Well-humified peat is usually found in large quantities within the widespread blanket bog of the interior of Lewis. The nearest area to the Bhaltos peninsula would have been the adjacent Uig Peninsula, with its more rolling topography, encouraging the widespread formation of blanket bog. The recurrent pattern of the well-humified samples on the biplot across the three sites also implies that the sites procured and managed the peat banks from potentially the same place. This suggests an element of co-operation between the sites in terms of resource procurement, perhaps involving communal effort in the peat gathering. It also points to a long-term stability in the division and tenure of the peatlands, as occupation of the three sites spans over half a millennium.

***Acknowledgements** (for Appendices 2 and 3)*
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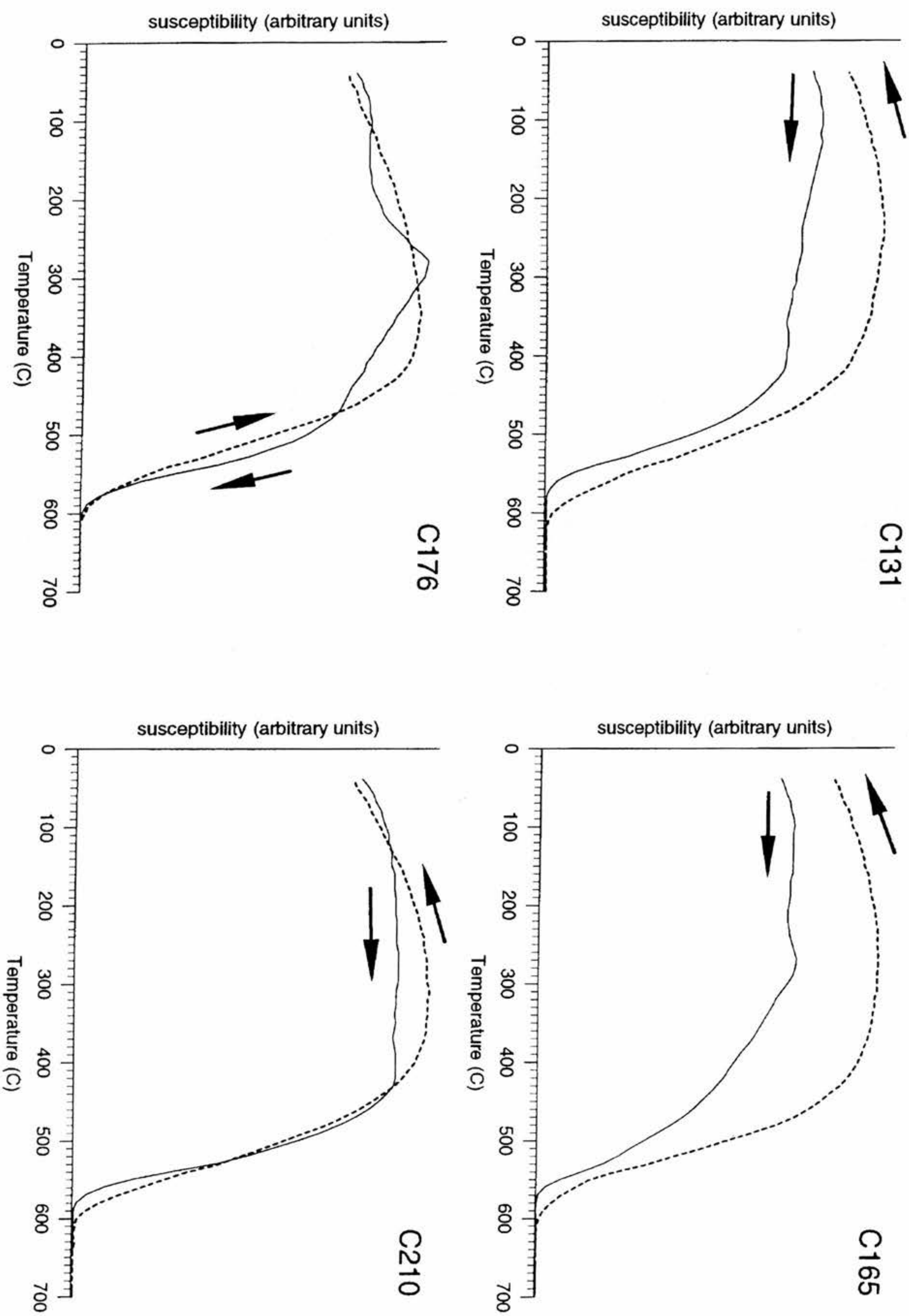

Figure 52: Susceptibility variation of four peat samples

Sample	Context	Generic context	Phase	Texture	Colour	Munsell
N/A	163	Occupation	Main CAR occupation	sandy silt	pale yellow	2.5Y 7/4
87/4	177	Occupation	Main CAR occupation	sandy silt	brown	7.5YR 4/2
87/8A	177	Occupation	Main CAR occupation	sandy silt	brown	10YR 4/3
87/8B	177	Occupation	Main CAR occupation	sandy silt	brown	10YR 4/3
N/A	206	Occupation	Main CAR occupation	clayey silt	black	2.5Y 2.5/1
87/6	176a	Occupation	Main CAR occupation	sandy silt	reddish grey	5YR 5/2
87/7	176b	Occupation	Main CAR occupation	sandy silt	reddish yellow	5 YR 6/8
N/A	158a	Occupation	Primary or pre CAR occupation	silty clay	light grey	2.5Y 7/2
N/A	158a	Occupation	Primary or pre CAR occupation	silt	very dark brown	2.5Y 2/7
Pit	158	Pit fill	Primary or pre CAR occupation	sandy silt	very dark grey	10YR 3/1
N/A	161	Gallery fill	Secondary occupation	sandy silt	very dark brown	2.5Y 2/7
N/A	164	Gallery fill	Secondary occupation	silty clay	dark greyish brown	2.5Y 4/2
87/9	204	Hearth foundation	Secondary occupation	clay	light grey	2.5Y 7/2
N/A	165	Hearth material	Secondary occupation	silty clay	very dark grey	5YR 3/1
N/A	203	Hearth material	Secondary occupation	silty clay	yellowish brown	10YR 5/6
87/13	210	Hearth material	Secondary occupation	sandy silt	dark yellowish brown	10YR 3/4
N/A	131a	Hearth material	Secondary occupation	clayey silt	brown	10YR 5/3
87/3	183	Wall clay bonding	Secondary occupation	clay	very pale brown	10YR 8/2
N/A	14	Wall fill	Secondary occupation	sandy silt	yellowish brown	10YR 5/8
N/A	137	Destruction layer	Secondary occupation destruction	clay	light grey	2.5Y 7/3

Table 2: Sub-sample description

Sample	Context	Moisture content (%)	Organic content (%)	pH	Magnetic susceptibility (High frequency) *	Magnetic susceptibility (Low frequency) *	χlf ~	κfd% ~
N/A	163	4.10	7.79	4.95	17	17.5	0.21	2.86
87/4	177	42.42	37.18	4.36	2.5	3	0.08	16.67
87/8A	177	17.59	20.28	4.49	47.5	51	1.26	6.86
87/8B	177	25.05	21.49	4.73	56	58	1.05	3.45
N/A	206	57.68	22.86	4.02	5	5	0.12	0.00
87/6	176a	29.11	30.48	4.61	248	266	5.26	6.77
87/7	176b	2.26	5.85	4.76	546	586	7.97	6.83
N/A	158a	28.95	2.18	4.58	3	3	0.03	0.00
N/A	158a	27.29	21.23	4.59	7.5	8	0.13	6.25
Pit	158	3.80	10.82	4.87	45	48	0.80	6.25
N/A	161	55.69	37.76	4.36	4.5	5	0.11	10.00
N/A	164	14.28	3.50	4.82	5	5	0.05	0.00
87/9	204	11.91	1.68	5.45	38	41	0.42	7.32
N/A	165	42.85	7.12	4.97	887	956	20.69	7.22
N/A	203	15.19	2.18	5.11	363	391	4.71	7.16
87/13	210	31.85	20.81	4.3	1525	1624	35.15	6.10
N/A	131a	33.45	11.76	4.6	858	924	15.17	7.14
87/3	183	1.12	1.86	4.73	30	31	0.30	3.23
N/A	14	9.43	21.73	4.47	1561	1601	18.86	2.50
N/A	137	2.00	3.39	4.74	38	39	0.42	2.56

Table 3: Sub-sample routine soil test results

* *Volumetric S.I. Units*

~ $10^{-6} m^3/kg$

APPENDIX 3

CARBONISED PLANT MACROFOSSILS AND CHARCOAL

by
Mike Church (Department of Archaeology, University of Edinburgh)

Introduction

This report analyses the carbonised plant macrofossils and charcoal recovered from the hand-retrieved and bulk samples taken from the land-based excavations at Dun Bharabhat, Lewis. A total of 25 samples were submitted for analysis, 15 of which produced carbonised remains.

Research basis

The samples were processed as part of doctoral research to produce a regional synthesis on the prehistoric use of plants in Lewis (see Appendix 2). A number of recurrent research questions were formulated for the archaeobotanical remains from each of these sites including;

1. Is it possible to propose generic taphonomic models for the origin, preservation and subsequent dispersal of the carbonised plant macrofossils on the site?

2. What materials were used for fuel?

3. What wood and timber was used and how was it procured?

4. Can aspects of arable agriculture be seen in the archaeobotanical record, from the crops grown to the crop-processing procedures employed?

5. What other plants were gathered and for what purpose?

Methods

On-site sampling

The sampling for the bulk samples has been outlined in Appendix 2, forming the basis of the sampling for both the archaeobotanical and sedimentary analysis.

Bulk sample processing

The bulk samples were processed using a flotation tank (Kenward *et al.*, 1980) with the residue held by a 1.0 mm net and the flot caught by 1.0 and 0.3 mm sieves respectively. All the flots and residues were dried and sorted using low-powered stereo/binocular microscope at x15-x80 magnification. All macrofossil identifications were checked against botanical literature and modern reference material from collections in the Department of Archaeology, University of Edinburgh. Generally, charcoal identifications were carried out on transverse cross-sections on fragments measuring from 4mm. Anatomical keys listed in Schweingruber (1992), in-house reference charcoal and slide-mounted micro-sections were used to aid identification. Asymmetry and morphological characteristics were also recorded. Nomenclature follows Stace (1991) with ecological information taken from Clapham *et al.* (1989), Stace (1991) and Pankhurst and Mullin (1994).

Results and discussion

Table 4 outlines the provenance, phasing and generic context type of the samples that contained plant macrofossils. The charcoal from the bulk and hand-retrieved samples is presented in Table 5, whilst the cereal and wild species are presented in Table 6 and 7. These results are interpreted below in terms of 1) the material from the occupation layers, with any differences between phases highlighted and 2) the hand-retrieved charcoal and bulk sample (C.169) from the destruction levels. The results are then discussed in terms of other assemblages within the Western Isles and Atlantic Scotland.

Occupation levels

Plant macrofossil taphonomy and fuel sources

As stated in Appendix 2, it is possible to propose from the site stratigraphy and sedimentary analysis two general taphonomic models for the preservation and subsequent dispersal of carbonised plant macrofossils across the site. The first involves the *in situ* burning represented by the destruction deposits (e.g. the hand-retrieved charcoal samples and C.169 bulk sample) and the hearth material (e.g. C.131a). The second involves the subsequent removal and dispersal of the plant remains from the central hearth into the surrounding occupation levels, such as S.87/4 and S.87/6. This can take the form of deliberate cleaning of the hearth by the occupants or gradual incorporation of small amounts of ashy material into the surrounding floor levels over time.

In Atlantic Scottish archaeobotany, it is necessary to disentangle the fuel-derived plant macrofossils from those relating to use of plants by humans. The detailed mineral magnetic analysis in Appendix 2 has demonstrated that ash of peaty turf and well-humified peat was recovered from the main complex Atlantic roundhouse (CAR) occupation and the secondary occupation respectively. Past research has shown that different fuel types produce varying numbers and proportions of plant parts and species (McLaughlin, 1980; Dickson, 1998; Church *et al.*, in prep. b). For example, peaty turf usually produces relatively large quantities of small culm bases and rhizome fragments, fibrous burnt peat and some seeds of the heathers (Ericaceae), grasses (Poaceae) and the sedges (*Carex* spp.). Well-humified peat however, produces relatively large quantities of a much more amorphous burnt peat and very few residual plant macrofossils, usually consisting of rhizome fragments. We would therefore expect to see this difference in the four samples analysed e.g. Contexts 131, 165, 210 (secondary occupation hearth material) and C.176 (ash spread in main CAR occupation layers). The three samples from the secondary occupation that were derived from well-humified peat ash correspondingly contained little residual material (a small culm base from C.210), apart from amorphous burnt peat fragments. Conversely, C176 contained a mix of fibrous and amorphous burnt peat fragments that would be expected for peaty turf (see Table 5). However, it did not contain any other residual material. This could be explained through different burning conditions to those from the experimental research (Church *et al.*, in prep. b), which could preclude the preservation of certain classes of plant material, such as seeds (cf. Wilson, 1984; Boardman and Jones, 1990). It therefore has proved possible to separate the few fuel-derived plant macrofossils from the bulk of the assemblage, which presumably relate to plants from other uses being incorporated into the hearths and resulting ash (*infra*).

Burnt peat fragments were examined from all the bulk samples, which demonstrated that amorphous peat was dominant within the secondary occupation samples, suggesting that well-humified peat was the major fuel source. The samples from the main and primary/pre-CAR occupation contained a mix between amorphous and fibrous peat, indicative of the use of both well-humified peat and peat turf as fuel. Edwards and Lomax (Appendix 1) outline a phase of increased inwash of eroded material into the loch that occurs throughout the first millennium BC. They suggest increased human activity, coupled with climatic deterioration, as the likely cause. It seems reasonable therefore to suggest that the peaty turf may well have been cut from the surrounding land, which would have made the catchment more susceptible to erosion. In the secondary occupation towards the end of the first millennium BC, more reliance was put on well-humified blanket bog that was probably cut outwith the catchment, on the Uig Peninsula for example. However, caution must be exercised when interpreting landscape change from a small sample assemblage.

Charcoal

Tree and shrub taxa include birch (*Betula* sp.), Ling heather (*Calluna vulgaris* L. Hull), hazel (*Corylus* sp.), pine (*Pinus* sp.) and spruce (*Picea* sp.) All the taxa, except the spruce, could have grown locally (Appendix 1). Nearly all the fragments were roundwood (i.e. from a twig or small branch), except for the pine and spruce. Very few fragments were recovered, which suggests accidental or residual burning rather than wood as a fuel. Indeed, it seems likely that the concentration of Ling heather fragments in C.158 (pre/primary CAR occupation) relates to the burning of peaty turf outlined above. Also, fragments of wood are commonly found in peat used as fuel, which could account for the presence of local taxa. However, the presence of a single fragment of spruce within C.131a points to the collection of driftwood that is discussed in terms of timber procurement in the section below. Generally, little interpretation on the use of trees and shrubs is possible from such a small assemblage.

Arable agriculture

Cultivated plants are represented by grains (caryopses) and rachis internodes of barley (*Hordeum* sp.) Where preservation allowed further identification (see Figures 57 and 58), most of the grains were hulled. The largest assemblage (54 cereal components) came from

C.158 (pre/primary CAR occupation) and contained 15 hulled grains and the only 2 naked grains on the site. It is impossible to evaluate whether naked barley was grown deliberately from such a small assemblage, as the naked grain could be an accidental contaminant of a hulled barley crop. The rachis internodes and asymmetric grains indicate the presence of six-row barley (H. *vulgare* L.), the dominant crop in Iron Age Atlantic Scotland.

It is likely that the grains were incorporated into the archaeological record through cooking accidents or during accidents in the final crop-processing stage for hulled barley. This involves drying the grain prior to the removal of the hulled material by gentle grinding, a process called graddening observed in the domestic setting of the Northern Isles in near-recent times (Fenton, 1982; Holden, 1998). This drying procedure necessitates exposure to heat, which could be achieved using the central hearth. It also requires a specific tool kit, such as saddle querns and grinders, a possible example of which was recovered from the occupation levels. This suggests that we are observing the final stage in the crop-processing procedure with the likely removal of the 'waste' products conducted off-site. However, some of this material can be brought on to the site for various uses, and then become accidentally carbonised on the central hearth. For example, a few cereal-sized culm bases and nodes from straw were recovered from five of the samples. The presence of the culm bases suggests that the crop was harvested by up-rooting, perhaps for ease but also to maximise the straw return from the crop. Also, C.206 contains a number of seeds and a six-row barley rachis that may represent further crop-processing debris, such as the remains from winnowing. The seeds from this sample are dominated by Wild turnip (*Brassica rapa* L.) with a few seeds of common Chickweed (*Stellaria media* L. Vill.), Fat Hen (*Chenopodium album* L.) and knotgrass (*Polygonum* sp.). All were common weeds of crops in prehistory, with Wild turnip a common weed of arable land in the machair. This issue of crops in the wider landscape is addressed below, with reference to the evidence from the destruction level and the off-site pollen record.

Gathered material and other useful plants

Little evidence was recovered for the gathering of other plants. Ling heather (*Calluna vulgaris* L. Hull) charcoal and leaf fragments were found in a few of the samples, which could have been used for furnishings and basket making, for example the peat basket found in the underwater excavations. However, the presence of burnt heather fragments can also be explained by the burning of turves from heathland.

Summary

The carbonised plant macrofossils from the occupation levels consist of a small assemblage with a low density and range of plant remains. They stem from the carbonisation of material within the central hearth and subsequent spread and dispersal into the occupation levels. Hence, the assemblage comprises 1) material derived from the fuel, 2) small fragments of charcoal 3) hulled barley grain from the final crop-processing stage or cooking accidents and 4) limited material, including straw, from earlier crop-processing stages.

Destruction level of secondary occupation

During the excavation, a destruction level from the secondary occupation was revealed across much of the interior of the roundhouse. The level consisted of lenses of burnt material, burnt bone and fragments of pottery interleaved between burnt timbers, some up to 60cms in length. These timbers were arranged in such a way as to suggest the fallen remains of a structural entity of the secondary building, the most likely candidate being the roof. Some of the timbers were sampled by hand and two bulk samples were taken from the interleaving lenses. C.137 was a sample of inorganic clay affected by heating (see Appendix 2) and C.169 on analysis appears to be the remains of a barley thatch.

Macrofossil preservation and taphonomy

All the plant macrofossils, from the thatch to the burnt timber are very well preserved. For example, the degree of preservation for all the grain from C.169 was compared to the grain from C.158, which was representative of the preservation from the occupation levels (see Figures 57 and 58). The two samples were compared using indices formulated by Hubbard (1990). Over 65% of the grain from C.169 lay within the two best preservation classes, indicating near perfect preservation, whereas over 85% of the grain from C.158 lay within the two worst preservation classes, indicating severe degradation of the grain. This allowed much more detailed identification to be possible for C.169 than is usually possible for material derived from the occupation levels from Atlantic Scottish sites. This excellent preservation stems from the carbonisation process that occurred during the presumed conflagration of the roof. The roof, if left to burn, would eventually have collapsed. This would have provided excellent conditions for slow carbonisation of plant material at a relatively low heat, within a reducing atmosphere (Gordon Thomas, pers. comm.). Experimental work by Boardman and Jones (1990) has shown that these conditions produce the best preservation, in terms of density, condition and the range of plant parts, many of which (the chaff, culms and seeds) would be destroyed in higher temperatures.

The destruction level is also important in terms of its taphonomy, because we can confidently relate the plant remains to specific functions. For example, the burnt timbers were used as structural components within the roof, whilst the cereal rich C.169 has been interpreted as a barley thatch, though it may be possible that it represents bedding, flooring or stored straw within the loft or roof of the structure. This degree of certainty when dealing with macrofossil taphonomy is very rare within Atlantic Scotland, because of the nature of the taphonomic models presented above. This removes the usual problems of taphonomic interpretation, so more confident and detailed analysis of issues such as timber procurement and arable agriculture are possible from such remains.

Timber

Five hand-retrieved samples were taken of the burnt timber. C.169 also contained fragments of burnt timber. The timber seems to be entirely composed of pine (*Pinus* sp.) and spruce (*Picea* sp.), with small amounts of birch (*Betula* sp.), Ling heather (*Calluna vulgaris* L. Hull) and rootwood of indeterminate taxa. The timber was in excellent condition and so identification was possible for most fragments, including the ring counts for all the fragments. The rings per fragment have been presented for the different taxa from all the hand-retrieved sample and C.169 separately. Figures 53 and 54 show the relatively low ring counts for the birch and Ling, with the highest counts being 16 and 8 respectively. Also, all the fragments were of roundwood suggesting that small branches and twigs were present within the roof, perhaps as furnishings such as heather rope or birch wattle. Both these taxa would have been available locally.

Figures 55 and 56 show the ring counts for all the spruce and pine from the hand-retrieved samples. All the fragments were of timber with the highest ring counts for the spruce and the pine 60 and 94 respectively. The high number of low ring counts reflects fragmentation following recovery of the charcoal, rather than the presence of roundwood or selection of smaller timber. The ring counts from C.169 (Figures 57 and 58) show a greater differentiation between the ring profiles of the two taxa, with less fragmentation of the charcoal within the comparative protection provided by a bulk sample. The pine seems to be of a greater age than the spruce, with the highest counts being 60 and 17 respectively. Further morphological characteristics provide information on the nature and origin of the timber. Several of the spruce fragments contained bore holes, which past researchers have taken as evidence for the use of driftwood (Malmros, 1994; Taylor, 1999). This seems to be the likely source for the spruce, as the taxa is non-native to the British Isles during the Iron Age. The timber could have drifted from North America or even Siberia, having first been transported through the Arctic (Dickson, 1992). The pine did not exhibit any sign of boreholes and bark fragments were recovered from C.169. Also, the ring pattern from the larger pine fragments was very narrow, which suggests the tree was growing in very stressed conditions. This evidence coupled with the presence of Scot's Pine (*Pinus sylvestris* L.) pollen in subzone BH2.IIIb (Lomax and Edwards, Appendix 1), suggests the use of locally-derived timber. Therefore the procurement strategies for timber were both opportunistic, in terms of the driftwood, and also potentially managed in the case of the locally-derived pine.

Thatch

As stated above, C.169 contained a high density of very well-preserved carbonised cereal plant macrofossils. Much of the plant material was derived from cereal straw including nodes, bases and thousands of culm fragments. The assemblage was therefore interpreted as a possible fragment of thatch. The straw crop seems to be a mix of six-row hulled barley (*Hordeum vulgare* var. *vulgare* L.) and two-row hulled barley (*Hordeum distichum* var. *vulgare* L.). From the proportions of the rachis fragments 73% of the assemblage was six-row with 27% two-row. Also, in two-row barley only symmetric grain is produced whereas six-row barley produces asymmetric and symmetric grain in a ratio of 2:1. Hence, the ratio of 1.4:1 within C.169 confirms a mix of six-row and two-row barley, with the six-row species dominant. The identification of two-row barley is surprisingly rare within the Atlantic Scottish Iron Age. This is partly because of the relative rarity in survival of those features (sterile lateral spikelet and rachis internode) that are used to differentiate the species but also may suggest sophisticated management of the arable resource through selective cultivation of specific species and variants for different functions. For example, the presence of two-row barley in a thatch may represent particular qualities the straw from this species exhibit.

The crop seems to have been harvested by uprooting, due to the high number of culm bases of both cereals and smaller monocotyledons and weed associations with low lying plants, such as the violets (*Viola* sp.). The straw would have been removed early in the crop-processing, during the threshing stage for example. This is confirmed by the ratio between the culm bases and the basal rachises (4.6:1), which shows that most of the ears were separated from the straw prior to its use as thatch. Hence, we can estimate approximately 80% efficiency for the separation of the ear from the straw during early crop-processing.

The presence of wild taxa within the straw presumably relates largely to weed contamination of the crop. Heather furnishings, such as rope or twine, can explain the limited presence of heathland taxa, such as *Erica*/*Calluna* spp. The remaining taxa are all common weeds of cultivation and dry grassland. The presence of Chickweed (*Stellaria media* L. Vill.) indicates relatively nitrogenous soil conditions, presumably enhanced through the addition of animal manure and seaweed to the soil. Several of the species, including Ray's knotgrass (*Polygonum oxyspermum* Meyer & Bunge ex Ledeb.), Bulbous *buttercup (Ranunculus bulbosus* L.) and Wild turnip (*Brassica rapa* L.) have strong associations with machair grassland (Pankhurst and Mullin, 1994). This evidence coupled with a second series of pollen sequences from Loch na Beirgh (Lomax, unpubl.), points to the cultivation of the crop occurring largely within the machair grassland behind Traigh na Beirgh. The presence of Wild turnip within the occupation levels (e.g. C206) may also point to the repeated use of the machair as the primary environment for arable cultivation.

Comparison to other sites

Bhaltos Peninsula

Dun Bharabhat was excavated as part of a wider investigation of the common structural Iron Age forms in the Western Isles (Harding and Armit, 1990). Two other structural forms, the wheelhouse complex at Cnip and the CAR and post-CAR occupation at Loch na Beirgh (Harding and Gilmour, 2000), were also excavated on the Bhaltos peninsula during this research campaign. Carbonised plant macrofossils have been analysed from both of these sites (Church, 1996; forth. a) and the assemblages, though different in certain details, are remarkably similar in their basic composition. For example, there is a strong correlation with the predominantly six-row hulled barley crop and Wild turnip, which suggests that all three sites were growing their crops in the machair over the half millennium that the sites were occupied, again supported by the pollen record (Lomax, pers. comm.). Scot's Pine (*Pinus sylvestris* L.) and coniferous non-native taxa, such as spruce (*Picea* sp.), were also recovered from the other two sites, along with a small assemblage of locally derived roundwood taxa. So again, timber procurement was through driftwood collection and local management. Also, as noted in Appendix 2, detailed mineral magnetic analysis of ash from all three sites has shown that the predominant fuel source was well-humified peat (Church *et al*., in prep. a), seemingly from the same localised position within extensive blanket bog. These striking similarities of plant use and management indicate co-operation between the occupants of the site, in terms of resource management. They also indicate long-term stability in not only these relationships, but also in the division and tenure of the different landscape zones, such as the peatland, machair and shore that lasted for over half a millennium (Ceron-Carrasco *et al.*, in prep.).

Western Isles and Atlantic Scotland

Several recent excavations at Iron Age sites in the Western Isles have yielded plant macrofossil assemblages and the results of these are summarised and compared by Church (forth. b), with general patterns of plant exploitation emerging. Driftwood is common on many sites (Dickson, 1992; Taylor, 1999), though few sites have large quantities of burnt structural timber like Dun Bharabhat. Most charcoal assemblages consist of low densities of locally derived taxa, similar to the assemblage from the occupation levels at Dun Bharabhat. Six-row hulled barley (***Hordeum vulgare*** var. ***vulgare*** L.) is the dominant crop, though the presence of two-row barley (H. ***distichum*** L.) is occasionally noted. Naked barley, usually of the six-row species (H. ***vulgare*** var. ***nudum*** L.), is also occasionally noted, with some sites, such as the Howe (Dickson, 1994), containing predominantly the naked variant. The cereal assemblages from most sites are dominated by grain, indicating that the crop is generally preserved in its final stages of crop processing, presumably during drying or cooking accidents. The weed associations with the crops are complicated because of the residuality of the fuels burnt in the hearths. However, a number of researchers have proposed likely zones of cultivation. For example, Smith (1999) suggests that the barley crop recovered from the Iron Age levels at Dun Vulan, South Uist was probably grown in the interface between the machair and the heathland interior. This zone would have been hundreds of metres from the site, being located within or adjacent to the machair plain during the Iron Age and this cultivation practice is clearly different to those employed by inhabitants of the Bhaltos Peninsula. Therefore, although a barley monoculture seems to dominate, actual cultivation practices change between different areas and regions. Regional variation also seems to appear between the procurement and use of fuel types. For example, the dominant fuel source for the Lewis sites appears to be well-humified peat (Church ***et al.***, in prep. a), with the large reservoir of blanket bog already established within the interior of Lewis by the early Iron Age. Preliminary mineral magnetic analysis of other sites from Atlantic Scotland, such as Cille Donain in South Uist (Batt and Peters, forth.) and Old Scatness, Shetland (Clare Peters, pers. comm.) have shown a much greater range in the fuels used, including wood, well-humified peat, peaty turf and fibrous peat. Hence, a picture of continuity and variation is emerging for plant use in the Atlantic Scottish Iron Age.

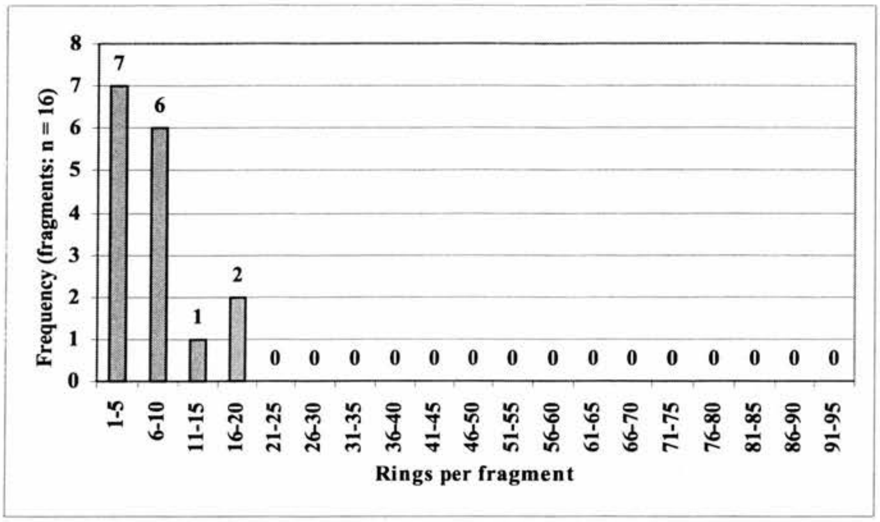

Figure 53: Rings per fragment for Birch (*Betula* sp.) from destruction level

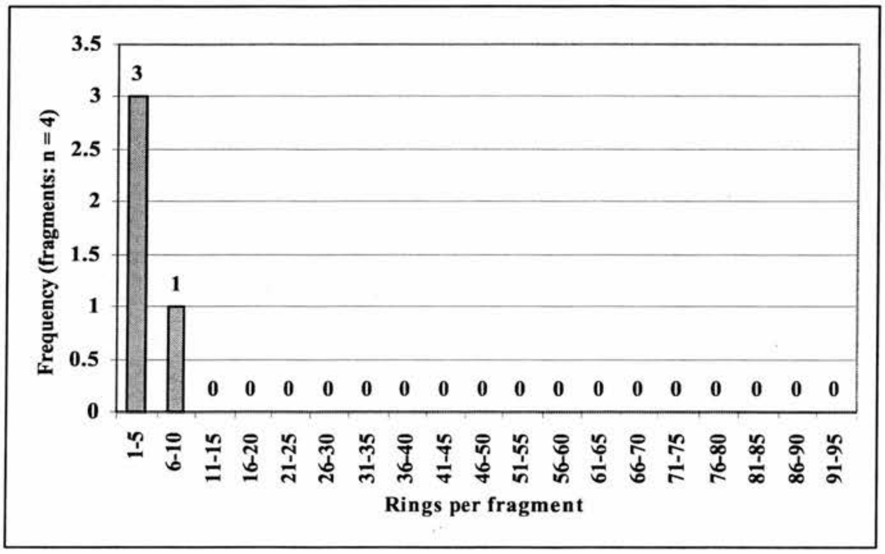

Figure 54: Rings per fragment for Ling heather (*Calluna vulgaris* L.) from destruction level

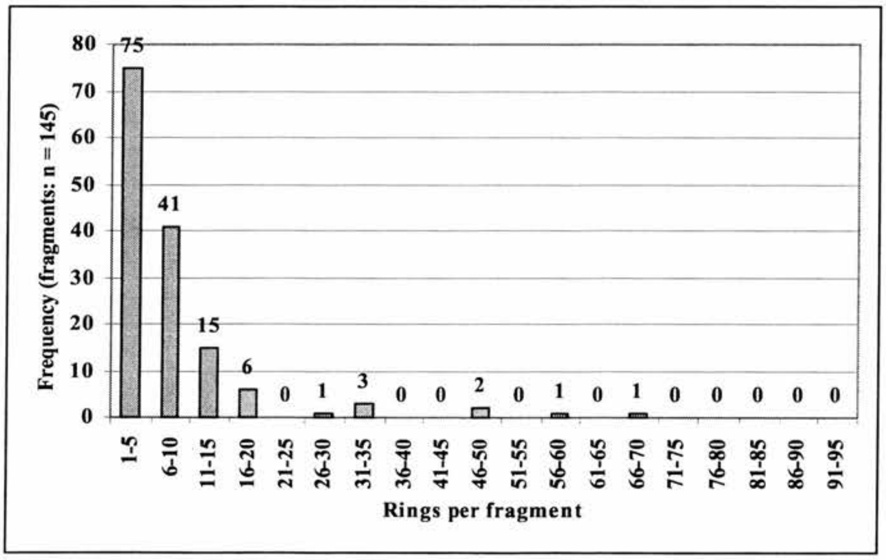

Figure 55: Rings per fragment for Spruce (*Picea* sp.) from destruction level

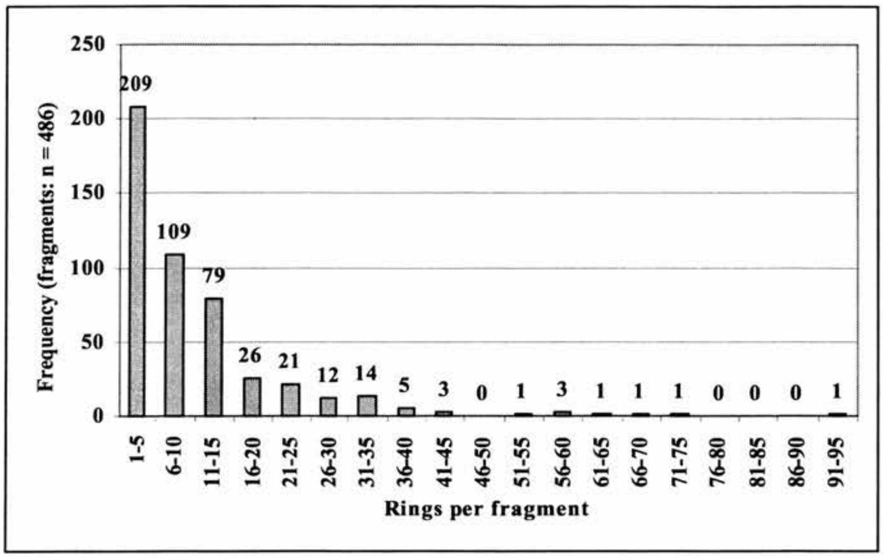

Figure 56: Rings per fragment for Pine (*Pinus* sp.) from destruction level

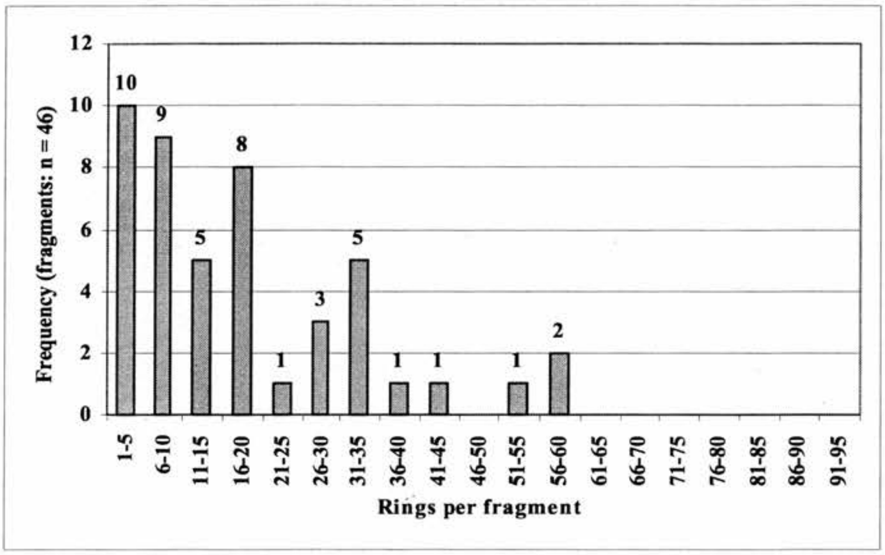

Figure 57: Rings per fragment for Pine (*Pinus* sp.) from C.169 bulk sample

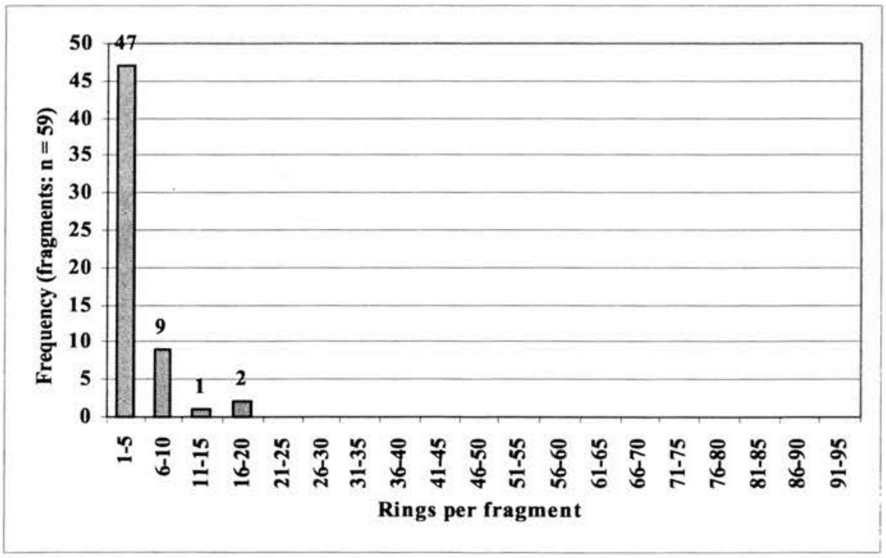

Figure 58: Rings per fragment for Spruce (*Picea* sp.) from C.169 bulk sample

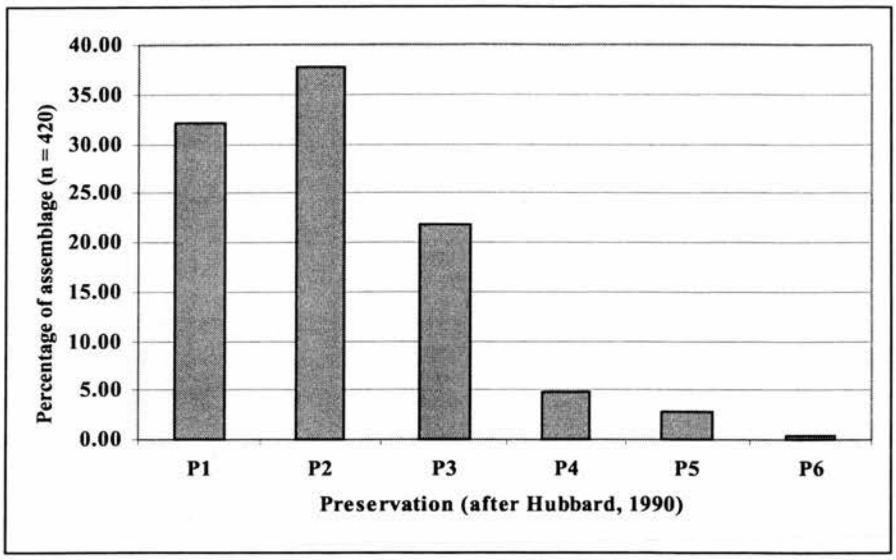

Figure 59: Preservation of grain recovered from C.169 (destruction level)

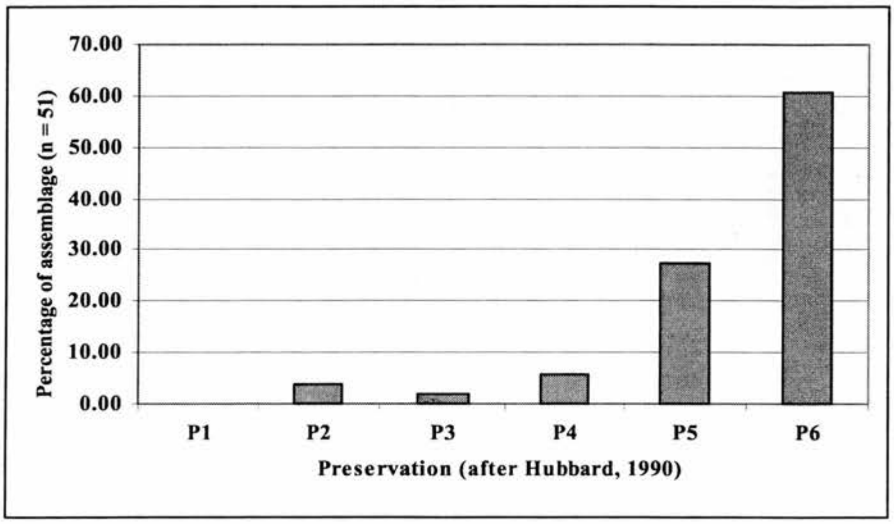

Figure 60: Preservation of grain recovered from C.158 (primary level)

Sample	Context	Volume (litres)	Phase	Phase notation	Generic context type
	128 N quad	n/a (hand retrieved)	Destruction	D	Destruction
	137B	n/a (hand retrieved)	Destruction	D	Destruction
	174	n/a (hand retrieved)	Destruction	D	Destruction
87/2	**181**	n/a (hand retrieved)	Destruction	D	Destruction
87/5	**186**	n/a (hand retrieved)	Destruction	D	Destruction
	169	5	Destruction	D	Destruction
	161	5	Secondary occupation	S	Gallery fill
	164	5	Secondary occupation	S	Gallery fill
	131a	5	Secondary occupation	S	Hearth
	165	5	Secondary occupation	S	Hearth
87/13	**210**	5	Secondary occupation	S	Hearth
	206	5	Main CAR occupation	M	Occupation
87/4	**177**	0.5	Main CAR occupation	M	Occupation
87/6	**176a**	5	Main CAR occupation	M	Occupation
	158	5	Primary or pre CAR occupation	P	Occupation

Table 4: Samples that contain plant macrofossils

Sample							**87/13**
Context	**158**	**206**	**161**	**164**	**131a**	**165**	**210**
Phase	**P**	**M**	**S**	**S**	**S**	**S**	**S**
Volume (litres)	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Betula sp. (birch) roundwood	2F (10.19)						
Calluna vulgaris (L.) Hull. (Ling heather) roundwood	17F (0.71)	1F (0.01)	1F (0.01)				4F (0.12)
Corylus sp. (hazel)					1F (0.02)		
Picea sp. (spruce)					1F (0.03)		
Pinus sp. (pine)	1F (0.01)	1F (0.01)				1F (0.01)	
Pinus sp. (pine) bark							
Indeterminate rootwood	6F (0.21)						
Indeterminate roundwood				1F (0.01)			
Indeterminate fragments	2F (0.08)						
Total fragments	28F	2F	1F	1F	2F	1F	4F
Total weight (g.)	1.20	0.02	0.01	0.01	0.05	0.01	0.12

Sample					**87/2**	**87/5**
Context	**169**	**128 N quad**	**137B**	**174**	**181**	**186**
Phase	**D**	**D**	**D**	**D**	**D**	**D**
Volume (litres)	**5***	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**
Betula sp. (birch) roundwood	2F (0.03)					16F (4.17)
Calluna vulgaris (L.) Hull. (Ling heather) roundwood	8F (0.57)		4F (0.48)			
Corylus sp. (hazel)						
Picea sp. (spruce)	59F (14.75)	24F (45.5)	73F (35.76)	23F (4.64)		25F (3.31)
Pinus sp. (pine)	46F (3.83)	43F (65.91)	103F (63.29)	122F (45.47)	113F (122.46)	105F (13.95)
Pinus sp. (pine) bark	3F (0.6)					
Indeterminate rootwood						
Indeterminate roundwood						
Indeterminate fragments	14F (1.07)					
Total fragments	132F	67F	180F	145F	113F	130F
Total weight (g.)	20.85	111.41	99.53	50.11	122.46	21.43

Table 5: Charcoal from all samples

* = Identification from 25% of charcoal greater that 4mm in C.169 bulk sample.

Sample				**87/4**	**87/6**					**87/13**	
Context		**158**	**206**	**177**	**176a**	**161**	**164**	**131a**	**165**	**210**	**169**
Volume (litres)		**5**	**5**	**0.5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Phase		**P**	**M**	**M**	**M**	**S**	**S**	**S**	**S**	**S**	**D**
Cereals											
Hordeum											
H. sp. caryopsis	Barley grain	11									
H. sp. basal rachis	Barley basal rachis										34
H. hulled caryopsis	Hulled barley grain	9			2				2		77
H. cf. Hulled caryopsis	cf. Hulled barley grain	6							1		
H. hulled asymmetric caryopsis	Hulled barley twisted grain							1			185
H. hulled symmetric caryopsis	Hulled barley straight grain										133
H. naked caryopsis	Naked barley grain	1									
H. cf naked caryopsis	cf. Naked barley grain	1									
H. *distichum* var. *vulgare* L. rachis internode	Two row hulled barley rachis										28
H. cf. *distichum* var. *vulgare* L. rachis internode	cf. Two row barley rachis										28
H. *distichum* var. *vulgare* L. basal rachis	Two row hulled barley basal rachis										9
H. *distichum* var. *vulgare* L. caryopsis	Two row hulled barley grain										4
H. *distichum* var. *vulgare* L. sterile lateral spikelet	Two row hulled barley sterile lateral spikelet										42
H. *vulgare* var. *vulgare* L. rachis internode	Six row hulled barley rachis	1	1						1		150
H. *vulgare* var. *vulgare* L. basal rachis	Six row hulled barley basal rachis										23
H. *vulgare* var. *vulgare* L. asymmetric caryopsis	Six row hulled barley twisted grain										7
H. *vulgare* var. *vulgare* L. symmetric caryopsis	Six row hulled barley straight grain										14
Cereal indeterminate caryopsis	Cereal grain	23		1							
Cereal indeterminate culm fragment	Cereal straw fragment										1000F+
Cereal indeterminate culm base	Cereal straw root base	1 (1F)						1	1	1	302 (10F)
Cereal indeterminate culm node	Cereal straw node	1		1						1	1299 (55F)

Table 6: Cereal carbonised plant macrofossils from bulk samples

Sample				**87/4**	**87/6**					**87/13**	
Context		**158**	**206**	**177**	**176a**	**161**	**164**	**131a**	**165**	**210**	**169**
Volume (litres)		**5**	**5**	**0.5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Phase		**P**	**M**	**M**	**M**	**S**	**S**	**S**	**S**	**S**	**D**
Weed seeds											
Ranunculus cf. *repens* L. fruit	Creeping buttercup										1
Ranunculus cf. *bulbosus* L. fruit	Bulbous buttercup										1
Stellaria media (L.) Vill. seed	Common chickweed	2	1								1
Chenopodium album L. seed	Fat-Hen		1								
Polygonum cf. *oxyspermum* Meyer & Bunge ex Ledeb. fruit	Ray's Knotgrass										2
Polygonum cf. *aviculare* L. fruit	Knotgrass										8
Polygonum sp. fruit	Knotgrass		2								3
Viola sp. fruit	Violet										7
Brassicaceae undiff. capsule base	Cabbage family										2
Brassica rapa L. seed	Wild turnip	1	39			5					155
Brassica/Sinapis spp. seed	Cabbage/Charlock						1				
Erica/Calluna spp. capsule/ovary	Heather	4				1					2
Erica/Calluna spp. stem/leaf	Heather										3F
Calluna vulgaris (L.) Hull stem/leaf	Ling										18F
Erica tetralix L. stem/leaf	Cross-leaved heather										4F
Galeopsis tetrahit L. seed	Common hemp-nettle										
Poaceae undiff. (medium) caryopsis	Grass grain	1				2					3
Poaceae undiff. (medium) floret/spikelet	Grass spikelet										7
Carex sp. (trigonous) fruit	Sedge						2				
Monocotyledon culm base	Monocotyledon straw root base									1	169
Monocotyledon culm node	Monocotyledon straw node	1									109 (13F)
Monocotyledon rhizome	Monocotyledon rhizome fragment										4F
Indeterminate seed/fruit	Unidentifiable										10
	Totals										
	Total grain components	**51**		**1**	**2**			**1**	**3**		**420**
	Total chaff components	**3**	**1**	**1**				**1**	**2**	**2**	**1915**
	Total cereal components	**54**	**1**	**2**	**2**	**0**	**0**	**2**	**5**	**2**	**2335**
	Total wild species	**7**	**43**			**8**	**3**			**1**	**480**
	Total quantifiable components	**61**	**44**	**2**	**2**	**8**	**3**	**2**	**5**	**3**	**2815**
	Quantifiable components/litre	**12.2**	**8.8**	**4**	**0.4**	**1.6**	**0.6**	**0.4**	**1**	**0.6**	**563**

Table 7: Wild species and summary totals of carbonised plant macrofossils from bulk samples

Pergamon

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Mineral Magnetism and Archaeology at Galson on the Isle of Lewis, Scotland

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Abstract. Coastal erosion is cutting a section through a complex later prehistoric archaeological site at Galson. 168 samples from individual features e.g. middens and hearths, and also from several continuously-sampled vertical profiles were collected from the site. A range of mineral magnetic measurements, including susceptibilities, and laboratory induced remanent magnetisations have been carried out on the samples. The strong magnetic signal of the hearth material can be traced in selected floors and middens giving an indication of the anthropogenic use within the dwellings. The magnetic data also highlight differences between visually similar soils. The variation of susceptibility with temperature, measured at 2cm intervals in a vertical profile through a hearth in one of the dwellings, has revealed two distinct magnetic mineralogies, with varying domain states, possibly reflecting different fuel sources.

1 Introduction

Mineral magnetism has previously been applied to archaeological studies e.g. by Yates (1988), Faßbinder and Stanjek (1993) and Peters and Thompson (1999), but is yet to be routinely used to aid archaeological interpretation. Mineral magnetism provides a simple, non-destructive technique for rapid measurement of soil, sand, sediment and rock in the laboratory. Here the technique is applied to an archaeological site on the Isle of Lewis, NW Scotland.

2 Archaeology

The site at Galson consists of a series of complex archaeological features exposed in the north-west facing eroding coastline of Lewis, Scotland (Fig. 1). The site was known to be actively eroding from past coastal erosion surveys (Cowie (1994), Burgess and Church (1997)). Past research has revealed two major levels in the eroding section ; a number of Iron Age burial cists from old ground surfaces which sporadically appear approximately half way up the section (Stevenson (1954), Ponting and Bruce (1990), Neighbour et al. (forth.)), and domestic dwellings with associated palaeosols and middens of Iron Age to Medieval date towards the top of the eroding section (Edwards (1924), Baden-Powell and Elton (1937)). The principal archaeological features investigated consisted of two separate houses in the upper level with associated middens and palaeosols. The eroding face revealed the internal cross-section of the houses ; including revetment walls, floor levels and hearth deposits. The structural morphology of both houses, and their potentially subterranean poly-cellular character, suggests that they are Late Iron Age in date at earliest. This is supported by the recovery of probable Iron Age pottery from the floor surfaces of the southern house (Cell A). Whilst no diagnostic pottery was recovered from the northern house (Cell B), it overlay, and hence post-dates the level from which the mid Iron Age cists have been previously excavated. A third cell (C) was identified with a central hearth, but the indistinct nature of the associated features precluded more detailed identification of the structure (Church, 1998).

3 Samples

168 samples were collected from the Galson site using two different sampling strategies. These were :

- 28 samples from individual features e.g. hearths and floors of the three dwellings.
- Four detailed and continously sampled (at 2cm intervals) vertical profiles, MS1-4, totalling 140 soil /

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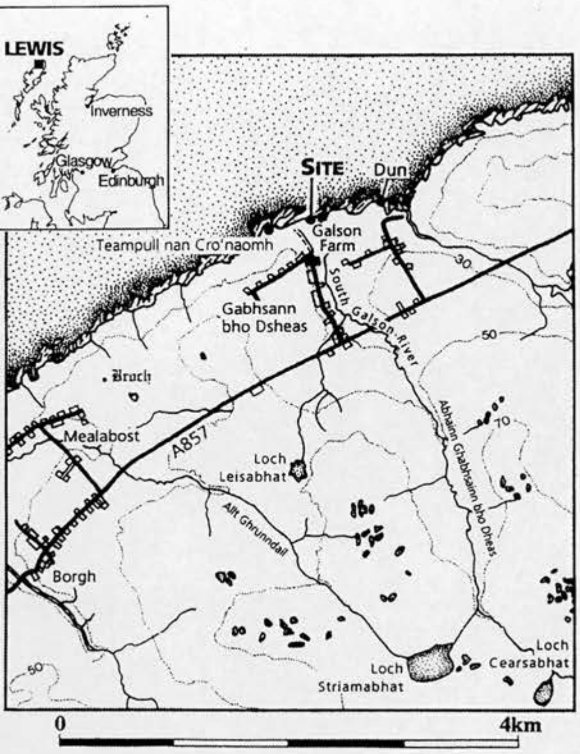

g. 1. Location map of Galson.

sand samples from the interior (MS1) and exterior (MS2) of Cell B and the hearth (MS3 and MS4) exposed in Cell C.

Magnetic Measurements

ne measurements made in the present study were based inducing or growing magnetisations in the laboratory f Thompson and Oldfield (1986)). The following measurements were carried out :

- Mass specific susceptibility (χ_{in}), frequency dependent susceptibility (χ_{fd}) and the variation of susceptibility with high temperature (up to 700^oC), were measured using a Bartington MS2 susceptibility bridge.
- Anhysteretic remanent magnetisations (ARMs) were grown using an adapted Molyneux AC Demagnetiser, with a peak alternating field of 99mT superimposed on a direct field of 0.1mT. Alternating field demagnetisation of the initial (saturation) ARM (SARM) was also carried out. All remanent magnetisations were measured using a Molspin fluxgate magnetometer.
- Isothermal remanent magnetisations (IRMs) were grown using a pulse magnetiser (up to 300mT) and electromagnets (1T), and were measured using a Molspin fluxgate magnetometer.

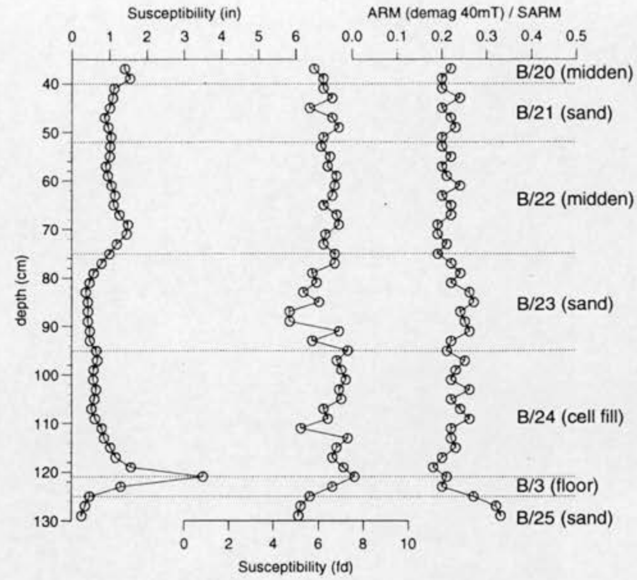

Fig. 2. Variation of $\chi_{in}(\mu m^3 kg^{-1})$, $\chi_{fd}(\%)$ and $ARM_{demag40mT}/SARM$, with depth for profile MS1 (interior of cell B).

5 Results

5.1 Profiles

Figures 2 - 4 display the variations of χ_{in}, χ_{fd} and $ARM_{demag40mT}/SARM$ with depth for profiles MS1 - MS3. χ_{in} gives a rough indication of magnetic concentration. A high narrow peak in χ_{in} is observed near the base of profile MS1 in Fig. 2, corresponding to the floor level (B/3) within the dwelling. No burnt clay material was observed, therefore the peak in χ_{in} is interpreted as fire ash, which has a high magnetic concentration, and is derived from the hearth within the dwelling. In profile MS2 (Fig. 3), contexts B/2, B/1, B/22 and B/20 are middens. The high χ_{in} values of midden B/1 suggests that a significant amount of fire ash has been dumped on midden B/1, whereas very little, if any ash, has been dumped on the other middens, reflecting differing anthropogenic use. In both profiles, MS1 and MS2, an increase in χ_{in} is observed over the merging boundary of contexts B/22 and B/23. Samples from the lower sections of context B/23 (sand) have very uniform magnetic concentration, however χ_{in} increases almost linearly during the upper sections of B/23 and continues to increase until it peaks in the lower sections of B/22 (midden). The similarity in both profiles thus allows direct correlation during the period of time after the dwelling was abandoned. Profile MS3 (Fig. 4) displays very high χ_{in} values compared to profiles MS1 and MS2. With the exception of the top three and bottom five samples of profile MS3, the samples are pure fire ash hence the χ_{in} values of up to 68 $\mu m^3 kg^{-1}$. The other eight samples are dominated by sand hence the reduced

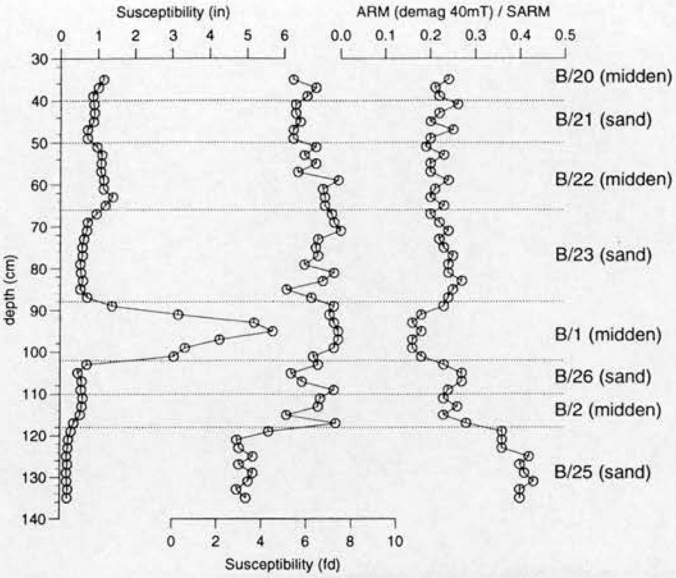

Fig. 3. Variation of $\chi_{in}(\mu m^3 kg^{-1})$, $\chi_{fd}(\%)$ and $ARM_{demag40mT}/SARM$, with depth for profile MS2 (exterior of cell B).

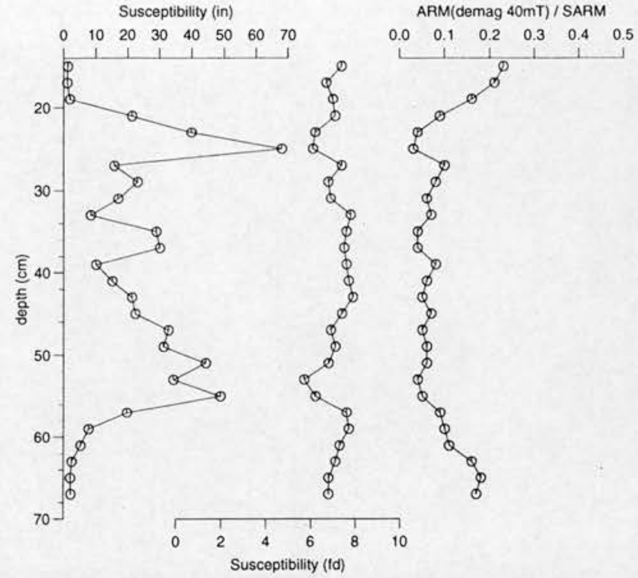

Fig. 4. Variation of $\chi_{in}(\mu m^3 kg^{-1})$, $\chi_{fd}(\%)$ and $ARM_{demag40mT}/SARM$, with depth for profile MS3 (cell C hearth).

χ_{in} values at the top and bottom of the MS3 profile.

χ_{fd} in Figs. 2 - 4 reflects the concentration of superparamagnetic (SPM) grains, which are very small in size, typically $< 300\AA$. In relation to archaeological soils SPM grains are generally associated with burning. The values of between 2.9 and 7.9 % for the three profiles indicate a mixture of SPM grains and coarser stable single domain (SSD) and multi-domain (MD) grains. The higher values indicate higher SPM concentrations. The highest χ_{fd} values are found in the ash samples of profile MS3 and the lowest in the underlying sand of profile MS2.

$ARM_{demag40mT}/SARM$ reflects variations in the domain state of the remanence-carrying component of the samples. Low values of $ARM_{demag40mT}/SARM$, for example the ash of profile MS3, shown in Fig. 4, suggest a high proportion of soft MD or viscous grains. Given the high χ_{fd} values for the ash samples, the low $ARM_{demag40mT}/SARM$ values are thus attributed to viscous grains rather than MD grains. The lowest context of profile MS2, B/25 (underlying sand), is distinguishable on the basis of its high $ARM_{demag40mT}/SARM$ ratios (Fig. 3). The high ratios indicate that these sand particles contain a higher proportion of SSD grains. Context B/1 is also distinguishable on the basis of its low $ARM_{demag40mT}/SARM$ values. The low values replicate those of the ash in profile MS3, strengthening the hyptothesis that midden B/1 contains a high proportion of fire ash.

5.2 Biplots

Biplots provide a useful way of comparing magnetic data. In Fig. 5 data from all the hearth samples from Cells B and C, midden samples from the interior and exterior of Cell B (contexts B/20, B/22, B/1 and B/2), sand samples from the Cell B profiles and floor samples from all three cells are presented. Characteristic magnetite and haematite data, taken from Peters (1995) are also included on the biplot of $SIRM/\chi_{in}$ versus $IRM_{60mT}/SIRM$ in Fig. 5. The grouping of all the Galson samples between intermediate and soft magnetite suggests that the observed magnetic variations are due to differences in domain state.

The biplots in Figs. 6 and 7 focus on the possible ash-containing materials i.e. hearth, midden and floor samples. The biplot of $SARM$ versus $IRM_{60mT}/SIRM$ in Fig. 6 distinguishes midden B/1 (with the exception of the top sample) from the other middens on the basis of magnetic concentration. The similarity between midden B/1 and the hearth samples further suggests the dumping of fire ash on that particular midden. Of the five floor samples, only three display characteristics comparable to the hearth material, thus implying that ash has not been trampled into all the floor surfaces sampled for the present study.

In contrast, the biplot shown in Fig. 7 of $SARM/\chi_{in}$ versus $SARM/SIRM$ distinguishes between the hearth samples and all the midden samples. The higher SARMs may be attributed to a small bacterial magnetosome component (cf Maher and Thompson (1999) and Barlow (1998)) within the more organic midden material. Bacterial magnetosomes are SSD in size, and therefore mag-

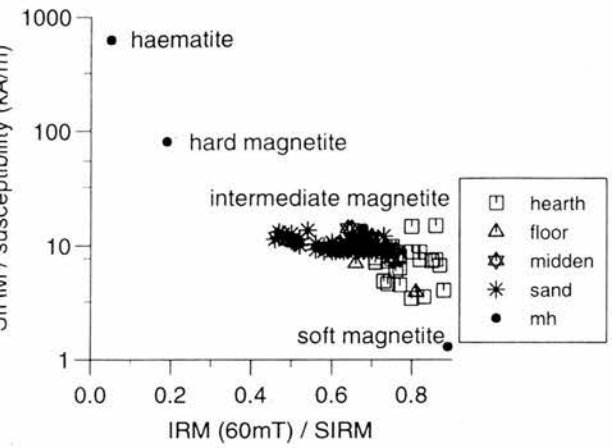

Fig. 5. Biplot of $SIRM/\chi_{in}$ versus $IRM_{60mT}/SIRM$ for all the hearth, floor and midden (B/20, B/22, B/1 and B/2) samples. Also included are representative magnetite and haematite data from Peters (1995).

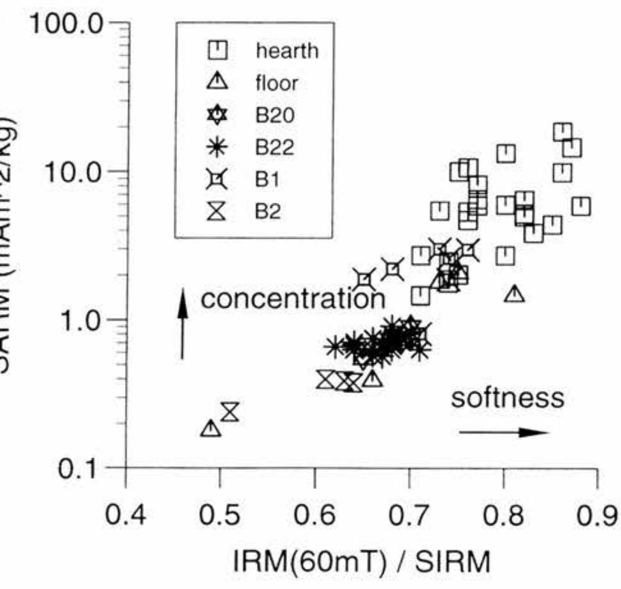

Fig. 6. Biplot of SARM versus $IRM_{60mT}/SIRM$ for all the hearth, floor and midden (B/20, B/22, B/1 and B/2) samples. The majority of midden samples from context B/1 display similar magnetic properties to the hearth samples.

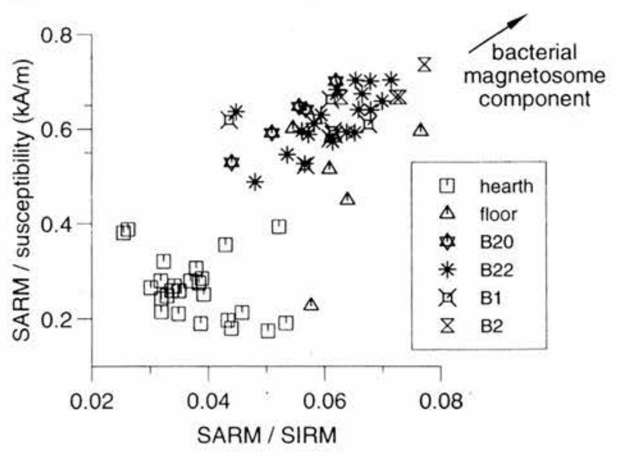

Fig. 7. Biplot of ARM/χ_{in} versus $ARM/SIRM$ for all hearth, floor and midden samples. The distinction between the hearth and midden samples is attributed to a possible bacterial magnetosome component.

netically hard as shown by the lower $IRM_{60mT}/SIRM$ values for the midden samplesf in Fig. 6. SD grains acquire ARMs most effectively and therefore the midden samples would be expected to display the highest SARM values in Fig. 6. However the observed low SARM values of the middens are due to a low concentration of bacterial magnetosomes compared to the very high concentration of magnetic grains within the ash particles of the hearth samples. In Fig. 7 only one of the five floor samples (compared to three samples in Fig. 6) display similar magnetic properties to the hearth samples. The overall magnetic signal observed in the floor samples appears to be a complicated mixture of ash and possible bacterial magnetosomes.

5.3 High Temperature Susceptibility

The variation of susceptibility with temperature (up to 700^oC) was monitored for all 27 samples from the vertical hearth profile, MS3. The resulting curves have been stacked according to their position in the profile and are shown in Fig. 8. Two distinct magnetic components with Curie Temperatures (T_c) of $\sim$ 330 and $\sim 580^oC$ are evident. The higher T_c is attributed to magnetite. The mineralogy of the reversible lower T_c is still uncertain. Variations in domain state are evident for the component with the low T_c. The linear change in susceptibility below 330^oC indicates SPM grains, whereas the convex-shaped curves indicate larger grains, possibly SSD. Mineral magnetic measurements carried out on modern ash samples of known fuel type suggest that the predominant fuel source of the MS3 ash samples is well-humified peat (Church et al., in prep.).

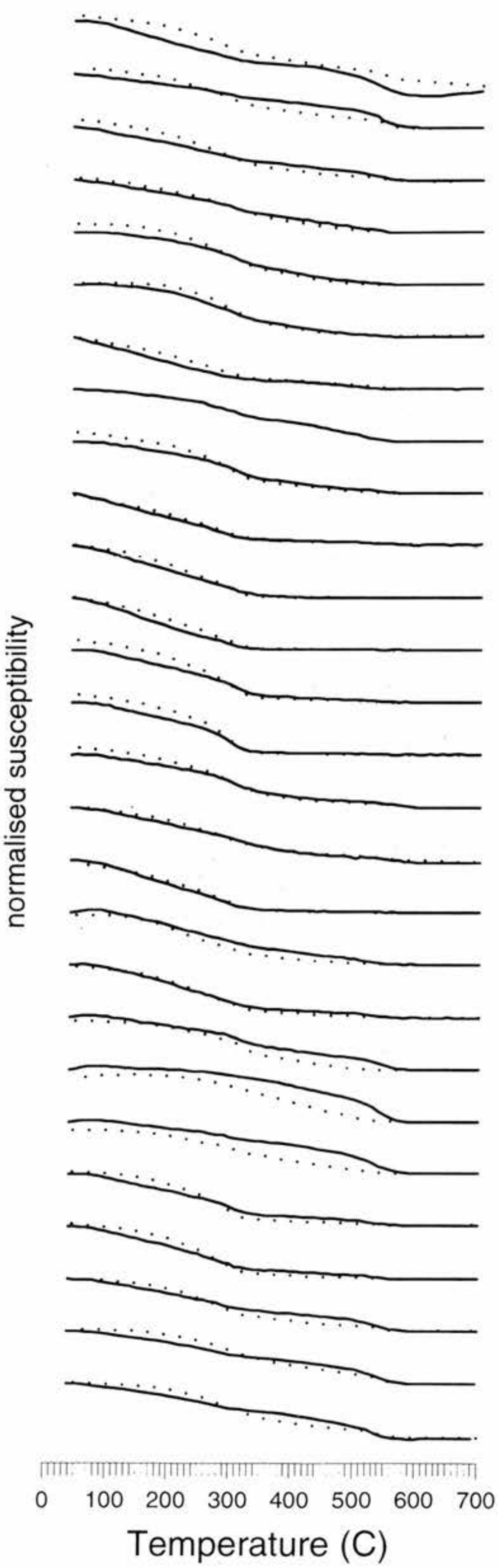

Fig. 8. The variation of susceptibility with high temperature for the 27 samples of profile MS3, stacked according to their profile position. The solid and dashed lines represent the heating and cooling curves respectively. The resulting curves show two distinct magnetic mineralogies of differing domain state.

6 Discussion

Archaeologically the implications for the use of these magnetic signatures across the site include the correlation of contexts which are not directly stratigraphically associated. For example within Cell B correlation between the hearth material (B/4), internal floor level (B/3) and the external midden which abuts the cell (B/1) is evident.

Other ways of using the magnetic signatures are for studying basic site formation processes when used in conjunction with standard archaeological procedures, such as routine and bulk sampling and soil micromorphology. For example the increase in magnetic concentration over the boundary of contexts B/22 and B/23 is reflected in both the internal (MS1) and external (MS2) profiles of Cell B (Figs. 2 and 3). The magnetic signature could also be used for identification of source and taphonomic pathways for burnt ecofacts, such as carbonised plant macro-fossils, into certain contexts. Use of the high temperature susceptibility measurements on ash samples can be used to differentiate fuel types (Church et al., in prep.), which can cast light on fuel use and procurement on site and in the wider landscape.

In the wider sense of aiding archaeological interpretation the magnetic measurements described here could be used as a possible tool for detailed context identification when evaluating sites for regional management of coastal erosion.

7 Conclusions

1. The research presented here demonstrates the use of mineral magnetism in archaeological prospection and interpretation of eroding sites.

2. The strong magnetic signal of ash can be traced in three of the five sampled floor levels and one of the middens.

3. Post-abondonment features can be correlated between the interior and exterior of cell B.

4. The observed difference between hearth and midden samples is attributed to a possible small bacterial magnetosome component in the more organic midden material.

5. The hearth samples contain two distinct magnetic components (with Curie Temperatures of $\sim$ 330 and $\sim 580^oC$) of varying domain states.

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Investigation of Fire Ash Residues Using Mineral Magnetism†

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ABSTRACT As part of a wider research programme of experimental archaeology at Calanais Farm, Isle of Lewis, Scotland, a number of experimental hearths were constructed, based on excavated evidence from the Late Iron Age houses at Bostadh, Lewis. Controlled and repeated burning of different fuel sources (well-humified peat, fibrous upper peat, peat turf and wood) was carried out over a number of burning episodes, each of three days duration. A range of mineral magnetic measurements, including remanences and the variation of susceptibility with high temperature, were taken from the resulting ash samples. The high temperature susceptibility measurements show that the fibrous upper peat and peat turf have a single magnetic component, with a drop in magnetic susceptibility at ca. 600 °C. In comparison the well-humified peat and wood have one, sometimes two, distinct magnetic components characterized by drops in susceptibility at ca. 330 and ca. 550 °C. Stepwise discriminant analysis was performed on the room temperature magnetic data. A biplot of the resulting two main variables distinguishes the well-humified peat and wood. Some overlap is observed between the fibrous upper peat and peat turf. Magnetic measurements also were carried out on Iron Age and Medieval hearth, floor and ash spread samples from the multiperiod archaeological site of Guinnerso, on the Isle of Lewis. Comparison was made with the modern ash samples in order to determine if fuel sources could be identified. The high temperature susceptibility curves and the discriminant analysis biplot suggest that for the selected archaeological samples the predominant fuel source was well-humified peat. Copyright © 2001 John Wiley & Sons, Ltd.

Key words: mineral magnetism; experimental archaeology; fuels; fire ash

Introduction

The use of fire in domestic and industrial capacities over past millennia has generated records through the ash deposits left behind of how people lived and worked. Burning produces an enhanced magnetic signal and thus fire ash is ideally suited to mineral magnetic studies. Despite the suitability and widespread use of magnetism in archaeological prospection and archaeomagnetic dating, only a few researchers have utilized environmental magnetic techniques to address questions of site formation, site function and ecofact and artefact taphonomy. Bellomo (1993) used mineral magnetic measurements in conjunction with other techniques to develop a method for identifying human-controlled fires from natural fires. Similarly, McClean and Kean (1993) have studied the magnetic properties of wood ash to determine the contribution of such ash to the magnetic signature of hearths as observed in magnetic prospection. Batt and Dockrill (1998) have integrated susceptibility, gradiometry and archaeomagnetic data with other

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archaeological evidence from the multiperiod site at Old Scatness, Shetland. This demonstrated the potential of environmental magnetism for dating purposes, site formation processes and modelling anthropogenic amendment of soils. Recent studies by Morinaga *et al.* (1999) and Linford (2000) have focused on how the magnetic properties of different substrates below fires react to heating. Peters and Thompson (1999) have developed a technique based on hysteresis loop data to quantify magnetic components, including superparamagnetism (associated with burning), within archaeological soils. In this paper we focus on the mineral magnetic properties of modern fire ash residues, produced under controlled burning conditions, with the aim of investigating the use of mineral magnetism to distinguish different burning regimes and application within archaeology. These applications include the investigation of site formation processes (cf. Batt and Dockrill, 1998; Peters *et al.*, 2000), the analysis of archaeobotanical taphonomy (Church, in preparation) and the reconstruction of fuel procurement and selection strategies (Church *et al.*, in preparation).

Methodological approach

Field basis of hearths

Three replica hearths were constructed based on the Late Iron Age three-sided hearths commonly uncovered in the Western Isles of Scotland. Each hearth measured approximately 0.6×0.4 m and was designed on the basis of the hearths excavated at the Late Iron Age site of Bostadh, in Great Bernera, Lewis (Neighbour and Burgess, 1997). The hearth slabs consisted of Lewisian gneiss, the common local rock, and they were placed into approximately 0.1 m of magnetically sterile beach sand from the beach at Bostadh.

Four basic fuel types were chosen; wood, well-humified blanket bog peat, fibrous upper peat and peat turf. These were chosen because evidence for their use on prehistoric sites is well attested in the archaeobotanical record across the Western Isles. The fuel was taken from two areas; the peat turf and fibrous upper peat from near Gearrannan (NGR NB 205 445) and the well-humified peat and wood from near Gearraidh na h-Aibhne (NGR NB 265 307). All the peat types were cut in springtime and dried and stacked for the summer. The wood came from dead pine trees (*Abies* sp.) from a plantation recently blighted by beetles.

Generally, a single fuel type was burnt in each replica hearth for a 72 h period, which allowed the construction, burning and sampling of a single hearth in one week. Following the burning, the hearths were allowed to cool before sampling. The colour of the ash produced was first recorded using a Munsell colour chart (Munsell, 1992). Multiple samples were then taken for mineral magnetic measurements, soil micromorphology and archaeobotanical remains. Here we will focus only on the mineral magnetic samples. The total volume of ash produced from each hearth was recorded before the remaining ash from each fuel type was dumped onto specially prepared areas covered by sterile beach sand. These dumps were sampled in the summer of 2000 and further sampling is planned for 2003 (five years after the initial dumping). The sampling will assess issues of ash spread and midden formation, exposure and erosion. It will also assess any short-term modification in magnetic properties of the material. Long-term modification, i.e. on an archaeological timescale, is much harder to assess. However, the common forms of post-depositional change, such as compaction and bioturbation, would not affect the magnetic properties, as they are mechanical in nature. Forms of chemical weathering and alteration present the greatest problem. However, most of the sites were covered by a significant overburden, sometimes metres in depth, which acted as a protective blanket for many of the archaeological layers. Also, the excavators at the sites mentioned encountered no obvious signs of chemical weathering and soil modification, such as iron pan formation.

Sample preparation

All the modern ash samples and the archaeological samples were dried and sieved at 2 mm. Subsequently, it was found that a better estimate of fuel types for the archaeological samples could be made if the ash component was isolated (see 'Archaeological applications' later) by sieving at 63 μm, thus removing sand and other large particles, which will contribute to the magnetic properties of the bulk sample. All samples were tightly packed into 2.5 cm cylindrical pots prior to the magnetic measurements being carried out.

Laboratory-based magnetic measurements

Mineral magnetic measurements are rapid, easy to measure and generally nondestructive. They provide information on the concentration of magnetic grains, the size of magnetic grains and the magnetic mineralogy (see Thompson and Oldfield, 1986). Observed differences in these three factors can be applied to investigating the formation and make-up of natural and archaeological materials. The following laboratory-based mineral magnetic measurements were carried out on all the modern ash samples and also the archaeological samples.

(i) Susceptibility measurements were carried out using a Bartington MS2 susceptibility bridge. Room temperature measurements of low and high frequency susceptibilities were carried out in order to determine the initial mass specific susceptibility (χ_{in}) and the frequency dependent susceptibility (χ_{fd}) for each sample. The χ_{in} value gives a rough indication of the total magnetic concentration and χ_{fd} provides an indication of the concentration of very small superparamagnetic grains. In addition the variation of susceptibility with temperature up to 700 °C was monitored for each sample. Information about the magnetic mineralogy and domain state can be obtained from the heating curve. Comparison of the heating and cooling curves provides information on the thermal history of the samples.
(ii) Anhysteretic remanent magnetizations (ARMs) were grown using an adapted Molyneux AC demagnetizer and measured using a Molspin fluxgate magnetometer. Two measurements were made for each sample; the saturation ARM (SARM) was grown in a peak alternating field of 99 mT superimposed on a direct field of 0.5 mT, and subsequent demagnetization of SARM in an alternating field of 40 mT. The SARM value gives an indication of the concentration of remanence-carrying grains and the ratio $ARM_{demag40mT}$ / SARM provides information on domain state.
(iii) Isothermal remanent magnetizations (IRMs) were grown using a Molyneux pulse magnetizer and also electromagnets, and were measured using a Molspin fluxgate magnetometer. The IRMs were grown in fields of 60 mT and the saturation IRM (SIRM) in 1 T. The SIRM value gives an indication of the concentration of remanence-carrying grains and the ratio IRM_{60mT} / SIRM provides information on domain state and mineralogy.

Results

Hearths

In the first season of experimentation 18 hearth cycles were run. The fire hearth numbers, fuel types and magnetic sample numbers are listed in Table 1. In general, one sample was taken from each fire hearth for mineral magnetic measurements. However, two samples were taken from each of the fire hearths FH1, FH5 and FH11 corresponding to observed differences in ash colour. Additionally profiles were sampled vertically through sections of fire hearths FH16, FH17 and FH18, resulting in multiple samples.

Magnetics

Figure 1 displays the biplot of χ_{in} versus χ_{fd} for 20 bulk and 23 sieved ash samples (excluding samples S106 and S133, which are mixed fuel types; data obtained only from sieved wood ash). The sieved samples show a higher magnetic concentration (χ_{in}) than the bulk samples, suggesting that sieving has isolated the more magnetic ash component from the sand and other large particles, which in general are only weakly magnetic. In Figure 1 differences between the fuel sources is beginning to emerge. Focusing on the envelopes drawn around the sieved data for each fuel type we observe complete discrimination between the four fuel types. The wood ash samples are characterized by lower χ_{in} values than the other fuel types. We also observe that the well-humified

Table 1. List of fire hearth numbers, fuel types and magnetic sample numbers: whp is well-humified peat, fup is fibrous-upper peat, pt is peat turf and wd is wood

Fire hearth number	Fuel type	Magnetic samples
FH1	whp	S9
		S10
FH2	fup	S15
FH3	wd	S21
FH4	whp	S32
FH5	fup	S37
		S38
FH6	wd	S44
FH7	whp	S54
FH8	fup	S58
FH9	pt	S62
FH10	whp	S70
FH11	fup	S75
		S76
FH12	wd	S81
FH13	whp	S95
FH14	fup	S98
FH15	mixture	S106
FH16	whp	S111
		S116(2)
		S116(3)
FH17	pt	S125(4)
		S125(5)
		S125(6)
FH18	mixture	S133(2)
		S133(3)
		S133(4)
		S133(5)

peat ash samples have higher χ_{fd} values (average of 7.9%) than the fibrous upper peat (average of 6.0%), which in turn have higher χ_{fd} values than the peat turf ash (average of 4.7%). Thus the biplot of χ_{in} versus χ_{fd} has produced, for the sieved data, a remarkable discrimination between the four fuel types based on differences in total magnetic concentration (χ_{in} distinguishing the wood ash) and the concentration of superparamagnetic grains (χ_{fd} separating the three types of peat fuel).

Discriminant analysis

The biplot of χ_{in} versus χ_{fd} in Figure 1 is the first step in attempting to discriminate the four fuel types. In order to make use of all the room temperature magnetic data, discriminant analysis was carried out. Discriminant analysis is a multivariate statistical procedure that compares variables from a number of groups and then combines them linearly to produce discriminant functions which show the greatest separation and least dispersion between the groups. The statistical package BMDP, subprogram 7M (Dixon, 1985) was used to carry out the multivariate discriminant analysis. Linear combinations of χ_{in}, χ_{fd}, ARMs, IRMs and their ratios have produced the two discriminant analysis variables shown in Figure 2. The main contributors to discriminant analysis variable 1 are SARM, SIRM and

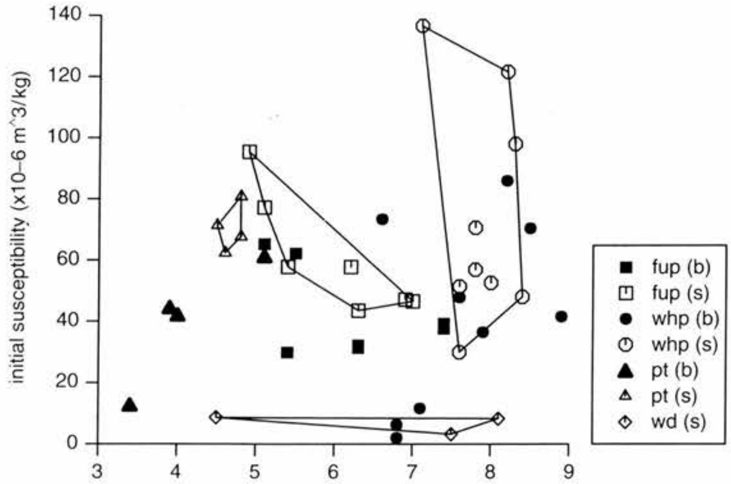

Figure 1. Biplot of χ_{in} ($\mu m^3 kg^{-1}$) versus χ_{fd}(%) for the 20 bulk (b) and 23 (s) sieved ash samples. Envelopes have been drawn around the sieved data for each fuel type to emphasize the discrimination: fup is fibrous upper peat, whp is well-humified peat, pt is peat turf and wd is wood.

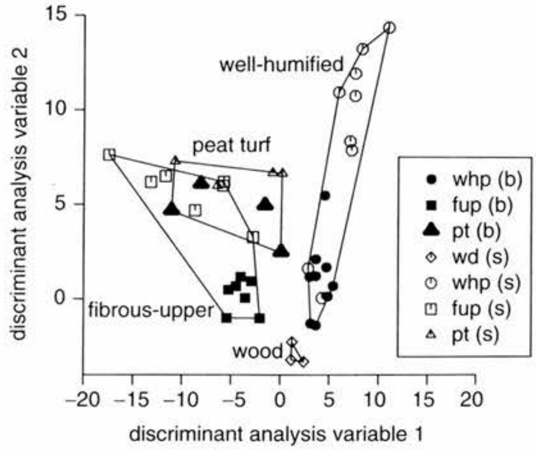

Figure 2. Results of stepwise discriminant analysis carried out on the room temperature magnetic data. The wood ash (wd) and well-humified peat ash (whp) are both distinguished from the fibrous upper peat ash (fup) and the peat turf ash (pt), which show some overlap. Data for the bulk (b) and sieved (s) ash samples are included.

$ARM_{demag40mT}/SARM$ and to variable 2, χ_{in} and $SARM/\chi_{in}$. The biplot discriminates the wood ash and the well-humified peat ash. Some overlap is observed between the peat turf ash and the fibrous upper peat ash. It is appreciated that the observed discrimination between the fuel types may contain a component of variability stemming from the area of peat extraction. However, at this preliminary stage of the experimental research project it is assumed that this variability is slight as the solid geology of the study area generally is uniform, with basement rocks of Lewisian Gneisses and few complex drift sequences in West Lewis (Gribble, 1994). Future experimental research will address this issue of variability, with regards to post-medieval township access to specific peatbanks.

High temperature susceptibilities

Figure 3 displays the variation of susceptibility with temperature for a selection of eight ash samples spanning the range of fuel sources. The peat turf ash and fibrous upper peat ash display similar characteristic curves, which

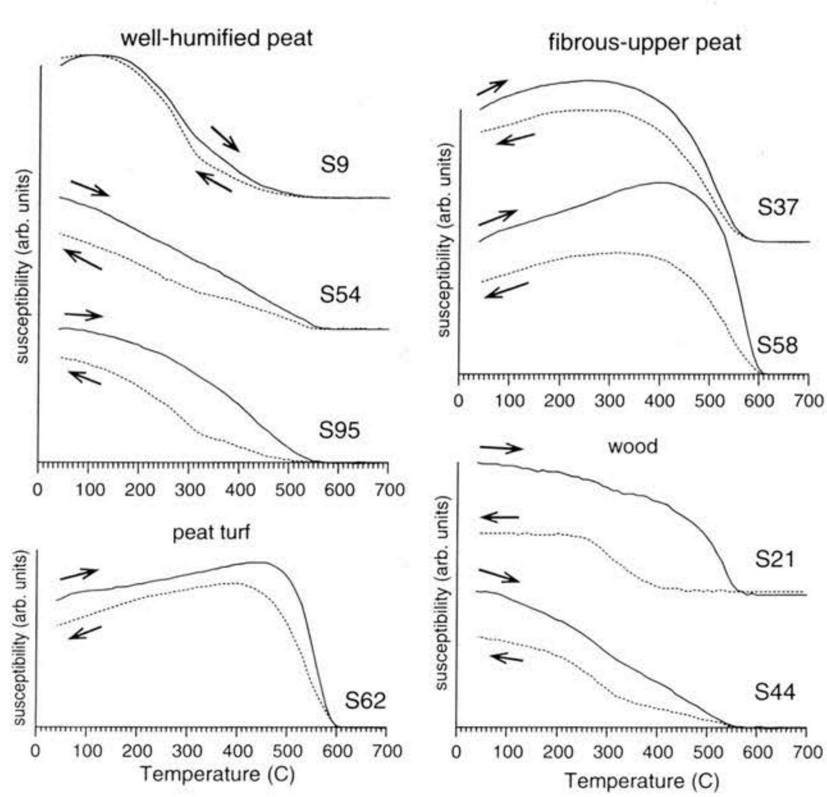

Figure 3. Variation of susceptibility with temperature for a selection of eight ash samples covering the range of fuel types.

increase in susceptibility with heating before dropping sharply by ca. 600 °C. In contrast, the well-humified peat ash displays drops in susceptibility at lower temperatures. One, sometimes two drops are observed at ca. 330 and/or ca. 550 °C. The wood ash curves are similar to the well-humified peat ash.

The three drops in susceptibility at ca. 330, ca. 550 and ca. 600 °C suggest three distinct magnetic mineralogies within the ash samples. At present the actual mineralogy of these three magnetic components is uncertain, but may represent modified magnetites or maghaemites. However, the observed difference between the fibrous upper peat/peat turf and the well-humified peat/wood is useful for corroborating the room temperature results displayed in the discriminant analysis biplot of Figure 2.

The thermal history of samples can be investigated by comparing the heating and cooling susceptibility curves, in particular comparison of the susceptibility at 40 °C pre- and post-heating. Samples previously heated to above 700 °C should display no increase in susceptibility after heating/cooling. The susceptibility curves in Figure 3 all show that after heating and cooling the susceptibilities at 40 °C are either lower or similar to the pre-heating values, indicating that during production of the ash temperatures above 700 °C were reached.

This information on thermal history is useful when considering plant macrofossil preservation. Boardman and Jones (1990) demonstrated through experimentation that the only plant macrofossils to survive above this temperature, in both reducing and oxidizing conditions, were the more resilient elements such as the cereal caryopsis. This may explain the dominance of poorly preserved cereal caryopses in many archaeobotany assemblages stemming from ash spread and discarded from domestic hearths across Atlantic Scotland (Church, in preparation). The less resilient cereal components, such as the chaff and other weed seeds, may have been totally burnt and destroyed.

Mixed fuel sources

For two of the fire hearth runs, FH15 and FH18, mixtures of fuel sources were burned instead of a single fuel type. Unknown quantities of the four fuel types were burned in both hearth runs. The fuel was burnt as single types rather than mixes of for example well-humified and peaty turf. Hence, layers of ash stemming from specific fuel types were overlain one on the other. A single ash sample was taken from FH15, S106, and a profile of four ash samples from FH18, S133(2) to S133(5). Values of the two discriminant analysis variables used in Figure 2 were calculated from the mineral magnetic data of the five bulk ash samples. The resulting values are shown on the discriminant analysis biplot in Figure 4. The mixed fuel type nature of the ash samples has indeed been highlighted by the magnetic data plotted in the form of the discriminant analysis biplot. The spread of the four samples from the profile through FH18 (S133) shows that within the build-up of the ash over a three day period individual fuel types as well as mixtures can be recognized. These results stem from the burning and subsequent sampling of individual fuel types within the three-day burning period of various fuels. It is appreciated that archaeological deposits from fires where fuels are mixed during the burning may produce results that are difficult to interpret. In that case, we assume that the fuel that produces the most ash would be reflected in the discriminant biplot and high temperature readings. Hence, it may prove difficult to identify burning episode of wood, interspersed with

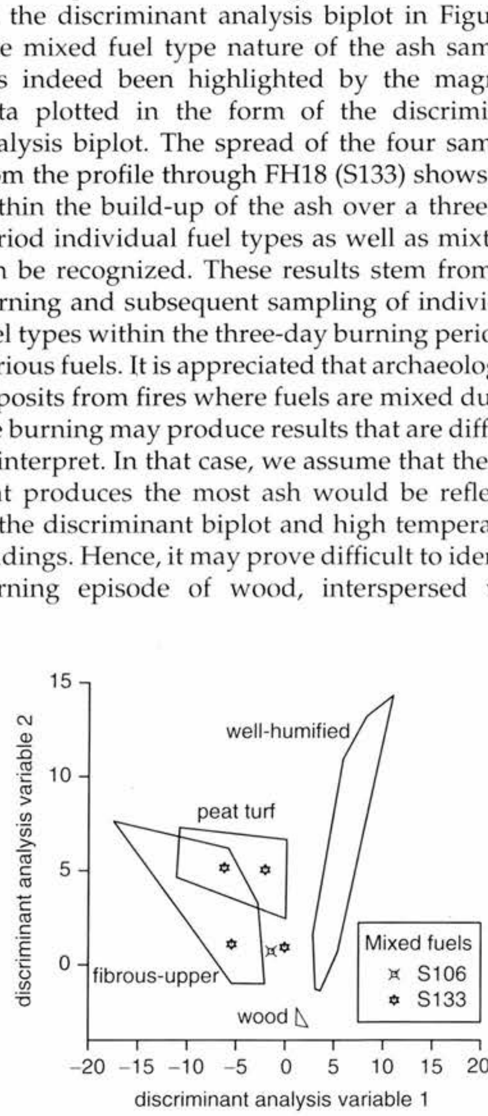

Figure 4. Discriminant analysis variables calculated for ash residues from fire hearths FH15 (S106) and FH18 (S133), which resulted from burning mixtures of fuel types.

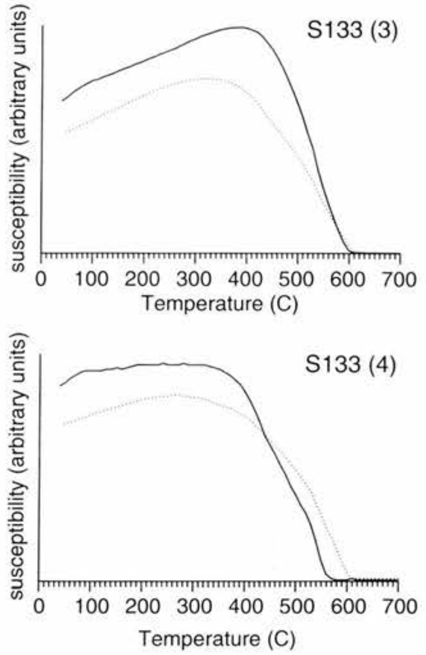

Figure 5. High temperature susceptibility curves for samples S133(3) and S133(4), from FH18 profile. The heating curves are shown by solid lines and the cooling curves by dashed lines.

burning of turf and peat, as the latter two fuels produce significantly more ash than wood does.

Figure 5 displays the high temperature susceptibility curves for two of the S133 ash samples. Sample S133(3) displays an increase in susceptibility before sharply dropping at 600 °C, characteristic of fibrous upper peat/peat turf ash. The heating curve for S133(4) shows a slight increase in susceptibility before loosing its magnetization by 560 °C, which can be interpreted as a mixture of fuel types dominated by well-humified peat ash. On the biplot in Figure 4, S133(3) is the top left-hand sample and S133(4) the bottom right-hand sample; thus the high temperature susceptibility curves are consistent with and confirm the results displayed on the discriminant analysis biplot in Figure 2.

Archaeological applications

Case study: Guinnerso

Magnetic measurements were also carried out on ash samples from the multiphase archaeological site of Guinnerso on the Isle of Lewis, Scotland (Church and Gilmour, 1999). A vertical profile, sampled at 2-cm intervals, was taken from an Iron Age hearth, resulting in nine samples. Initially, bulk samples were measured. The discriminant analysis variables calculated for the nine bulk hearth samples are displayed on the biplot in Figure 6. We observe that the bulk samples plot outwith the range of the fuel sources. Subsequent sieving of the samples at 63 μm, in an attempt to isolate the ash component from larger sand and other particles, and remeasuring of the <63 μm particle size fractions has produced the discriminant analysis variables labelled 'sieved' in Figure 6. The sieved samples plot within the range of the modern ash residues. The biplot suggests that the Guinnerso ash samples are dominated by well-humified peat, with a wood component in a couple of the samples. Fragments of heather were found in bulk samples from the hearth at a depth consistent with the wood ash readings.

The high temperature susceptibility curves for the profile are shown in Figure 7. The susceptibility is reduced to zero by ca. 550 °C in all samples. The heating curves are similar in nature to those of well-humified peat ash and wood ash in Figure 3. The cooling curves, however, are higher than the heating curves, indicating that particles that have not previously been heated to elevated temperatures are present within the archaeological samples; as the particles were heated, alteration

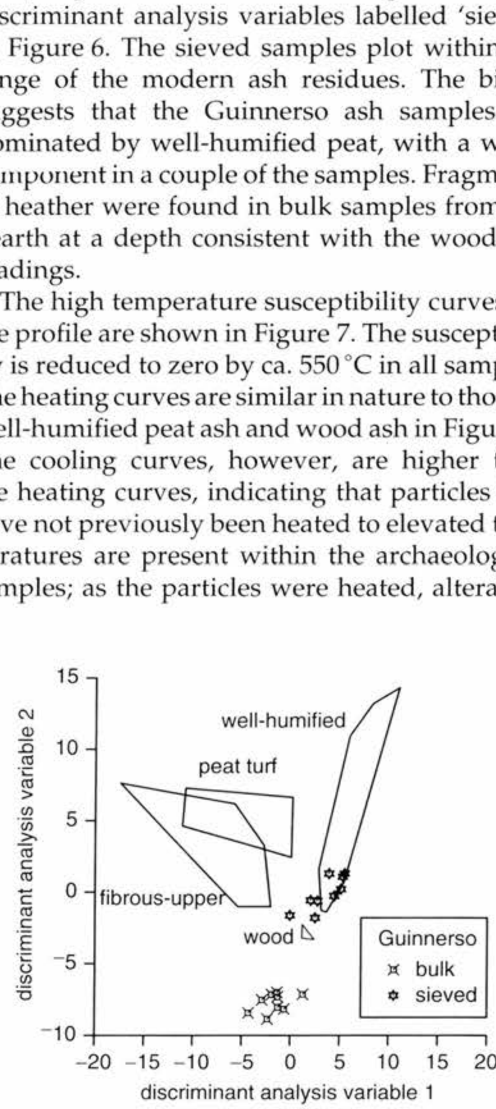

Figure 6. Discriminant analysis biplot (Figure 2) with the bulk and sieved Guinnerso hearth profile samples superimposed.

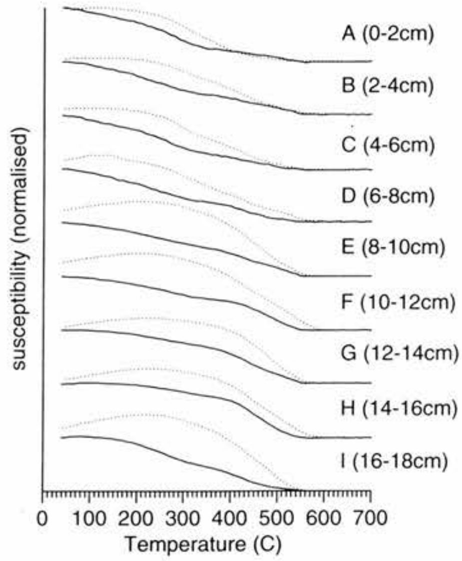

Figure 7. High temperature susceptibility curves for the nine samples from the Guinnerso Iron Age hearth profile. The heating curves are shown by solid lines and the cooling curves by dashed lines.

to a more magnetic phase occurred. Thus the two newly developed methods for determining fuel types, the discriminant analysis biplot and the high temperature susceptibility curves, both indicate that well-humified peat and wood, in the form of heather, were burnt in the Guinnerso Iron Age hearth.

Fire ash is of course not restricted to hearths on archaeological sites. Thus, samples from floors and ash spreads, in addition to hearth samples, from both the Iron Age and Medieval periods of occupation at Guinnerso have been analysed, to investigate how effective the technique is in identifying ash components within the floors and ash spreads. Figure 8 displays the discriminant analysis biplot for each of the four categories; Iron Age hearths, medieval hearths, Iron Age floors and ash spreads and Medieval floors and ash spreads. The hearth samples from both periods are clustered tightly. In comparison, the floor and ash spread samples from both periods display a much greater dispersion. Floors and ash spreads are not necessarily composed entirely of fire ash and therefore the magnetic grains within the fire ash may not be their sole magnetic component. One possible other magnetic component is bacterial magnetosomes. Biogenic precipitation of magnetite by magnetotactic bacteria is feasible within sedimentary and soil-forming environments at temperatures below 50 °C (Maher and Thompson, 1999). In order to investigate the possible effect of bacterial magnetosomes on the results of the discriminant analysis, Figure 9 was plotted. High values of SARM/SIRM versus SARM/χ were found by Barlow (1998) to indicate a bacterial magnetosome component within sediments. Peters *et al.* (2000) have used the same parameters to suggest a bacterial magnetosome component within archaeological deposits at the eroding Late Iron Age/Norse site at Galson on the Isle of Lewis. In Figure 9, we observe that four of the Iron Age floor and ash spread samples and three of the Medieval samples for Guinnerso plot in the upper right-hand section of the biplot, suggesting that bacterial magnetosomes may contribute to the overall magnetic make up of these samples. These seven samples have been indicated by circles in Figure 8. With the exception of one of the Iron Age samples, the samples without a high bacterial magnetosome component are more tightly clustered, and in the case of the medieval samples no longer display such a strong trend towards the peat turf. It is interesting to note that the three medieval and one Iron Age floor and ash spread samples with SARM/SIRM values less than those of the hearth samples in Figure 9, correspond to the samples with the highest values of discriminant analysis variable 2 in Figure 8, possibly indicating another, as yet unknown, magnetic component.

Use of the technique within archaeology

The technique has a number of possible applications to archaeological research. The identification of ash from different fuel types can aid in the interpretation of site stratigraphy and can complement those palaeoenvironmental techniques, such as soil micromorphology, that are used more routinely on archaeological sites in order to understand site formation processes. The identification of different fuel types also aids in the analysis of archaeobotanical assemblages as it allows the separation of those macrofossils that may have been introduced through the fuel from plants relating to other human uses. For example, past research has shown that different

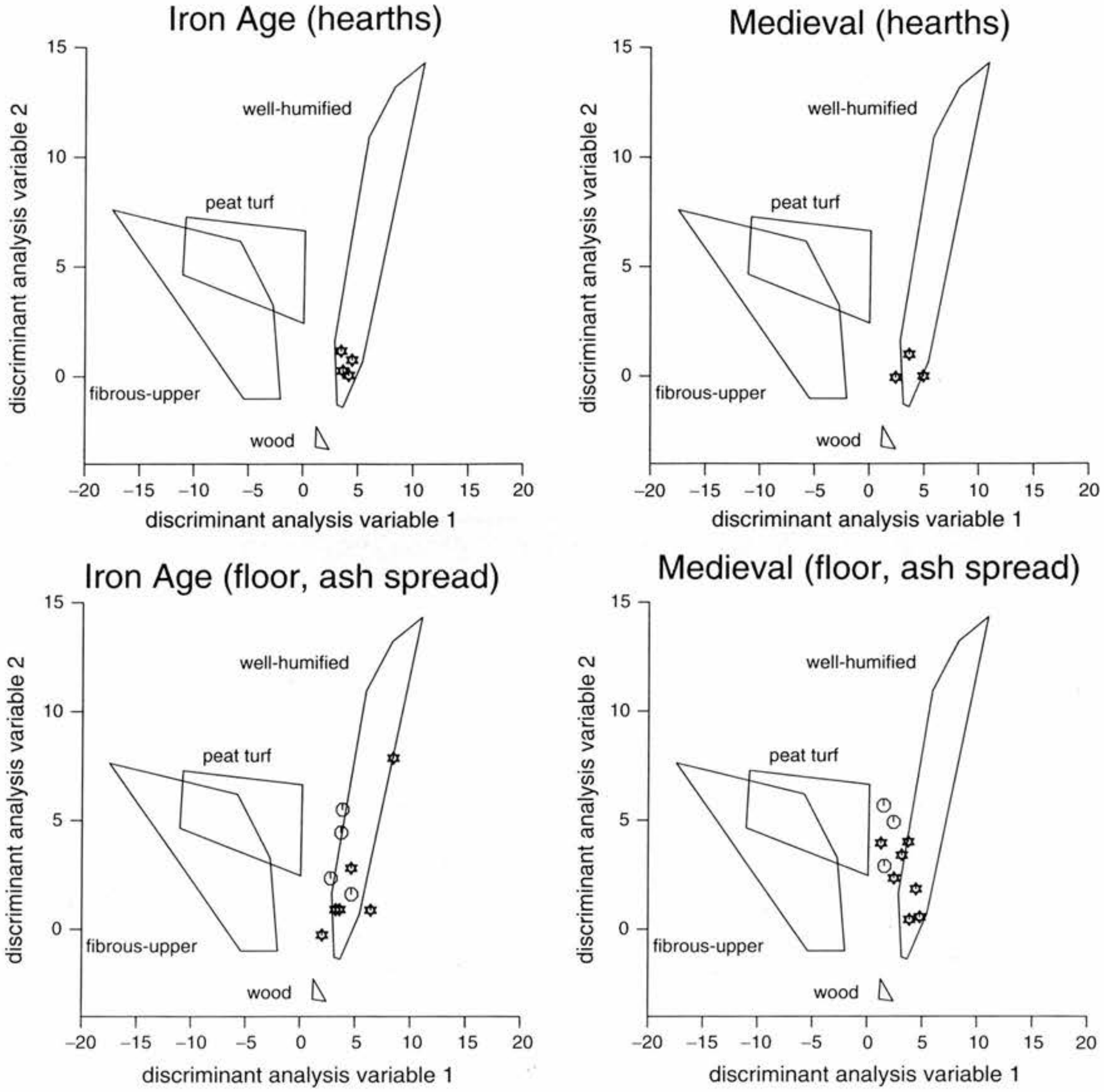

Figure 8. Discriminant analysis biplots for Iron Age and medieval hearth samples and floor and ash spread samples. The hearth samples cluster tightly in comparison with the floor and ash spread samples. The floor and ash spread samples denoted by circles are samples that were found to have higher bacterial magnetosome components (see Figure 9).

fuel types produce varying numbers and proportions of plant parts and species (McLaughlin, 1980; Dickson, 1998). A complementary proxy record, such as mineral magnetism, which can highlight the probable fuel source in which the plants were carbonized, therefore is an invaluable tool for archaeobotanical taphonomy. The information on thermal history also is useful when considering plant macrofossil preservation (see above). Finally, the technique has considerable interpretative value in terms of fuel procurement and selection strategies. This can be approached on an intra- and intersite basis over space and time. Detailed analysis has been undertaken for a number of archaeological sites in both the Western and Northern Isles, which demonstrates that a pattern of varied fuel procurement and selection existed across Atlantic Scotland in the later prehistory and early historic periods (Church *et al.*, in preparation).

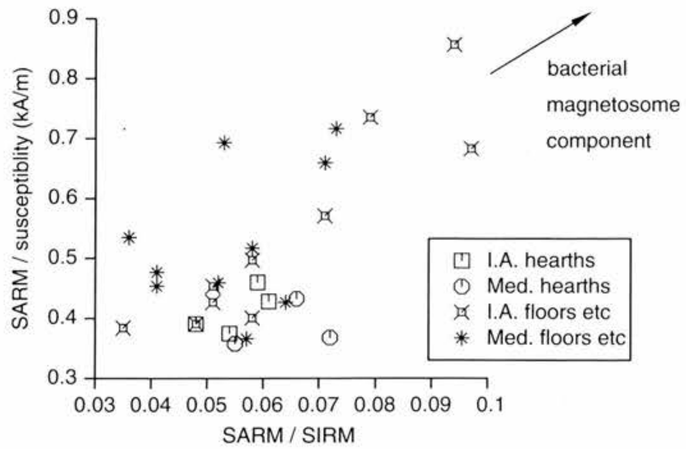

Figure 9. Biplot of the Iron Age and medieval hearths, floors and ash spreads. The combination of the parameters SARM/SIRM versus SARM/χ was found by Barlow (1998) to give an indication of a bacterial magnetosome component.

Conclusions

(i) Burning produces an enhanced magnetic signal, thus fire ash is ideally suited to mineral magnetic studies.

(ii) Discriminant analysis carried out on room temperature magnetic measurements of experimental ash residues of known fuel type has resulted in a biplot distinguishing well-humified peat and wood, and showing some overlap between fibrous upper peat and peat turf.

(iii) Measurements of high temperature susceptibilities carried out on the experimental ash residues show differences between well-humified peat/wood and fibrous upper peat/peat turf.

(iv) Trial application of the two magnetic techniques in investigating fuel types from ash residues excavated on archaeological sites looks successful in identifying the main fuel sources to be well-humified peat and wood from Iron Age and medieval samples from Guinnerso, Isle of Lewis.

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